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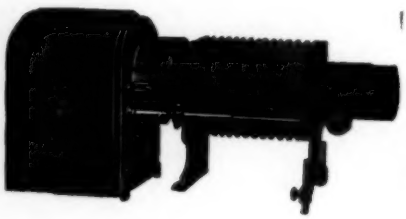

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XX, NO. 7 OCTOBER, 1920 WHOLE NO. 171

RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins,
University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

ACTIVATED NITROGEN.

BY F. O. ANDEREGG, *Professor of Physical Chemistry, Purdue University, Lafayette, Ind.*

One of the essential constituents of all living matter is nitrogen. One of the things the farmer has to worry about is how to secure nitrogen with which to grow his crops and yet there are tons and tons of this very valuable substance all about him for it comprises nearly four-fifths of the air. Above every square inch of the surface of the earth there are about twelve pounds of nitrogen. Unfortunately it is very inert. The inertness is caused by the combination of two nitrogen atoms, which are reactive enough by themselves, into a very stable molecule. The two atoms have such an affinity for each other that it is only with considerable difficulty that they can be pulled apart sufficiently to react with other substances—such as oxygen. It is the problem of the chemist to devise successful methods for activating nitrogen. How well this has been done is shown by the plentiful supply of ammunition with which the Germans provided themselves by activating atmospheric nitrogen for the formation of nitric acid which is necessary in making almost all explosives.

It is not the purpose of this discussion to take up the present practical methods for nitrogen fixation. There is a very considerable amount of literature on this interesting subject. Our

object is to discuss some of the less well known methods of activating nitrogen. It is true that these are not of present practical value, but the laboratory experiment of today which seems to have only theoretical importance becomes the basis for the practical method of tomorrow or of next year and so it behoves us as wide awake scientists to keep up with the times and perhaps even to anticipate them.

E. Percival Lewis of the University of California prepared some nitrogen chemically from ammonium nitrite and on subjecting this to a discharge from an induction coil at a pressure of a few millimeters of mercury he noted the formation of a pulsating yellow mist in the tube and which also extended outside the tube for some distance. On breaking the circuit the glow persisted for several seconds. In order to get this afterglow the purity of the nitrogen had to be carefully adjusted. If it was prepared from air and quite free from oxygen it gave very little if any glow. The chemically prepared material contained traces of nitric oxide which seemed, at first, to be necessary to catalize the reaction. Also a so-called condensed discharge appeared to work best. This was secured by placing a few Leyden jars in parallel with the discharge tube.

R. J. Strutt, an English physicist, has continued the study of this afterglow and has found that it has a great many peculiar physical and chemical properties. When the glowing nitrogen passed through a tube which was heated locally, the glow was extinguished but reappeared on the other side. When cooled by liquid air the luminosity increased momentarily and was then finally extinguished. Similarly on compression the glow was extinguished, indicating that the return to the inert form was a polymolecular reaction. The molecular change back to the ordinary inert nitrogen was then accelerated by cooling and retarded by heating. The glowing gas had a conductivity like a salt flame due to the presence of some ions; but on applying an electric field of two hundred volts to the luminous nitrogen, the glow was not diminished, indicating that the afterglow was not produced by nitrogen atoms or molecules, bearing charges.

Action on non metals: The chemical properties of glowing nitrogen were very interesting. In contact with phosphorus a violent reaction took place and some red phosphorus was deposited, and on precipitating the compound by cooling in liquid air over 15 mg. were secured from 2.5 liters of nitrogen, indicating

that nearly 0.5 per cent of the nitrogen had combined with phosphorus. When the glowing nitrogen came in contact with iodine vapor a magnificent light blue flame was produced. But on hydrolyzing the product with potassium hydroxide no trace of ammonia was secured. It might have been that iodine united with nitrogen as oxygen does, so that on hydrolysis nitric acid was formed rather than ammonia. In contact with warmed sulfur a bluish glow was formed with a green deposit on the glass. With selenium, arsenic, antimony and carbon, very little if any reaction was to be noted. When hydrogen was added the glow was diminished by the dilution but there was no evidence of ammonia formation. When oxygen was added to the active nitrogen the glow was simply extinguished, no trace of oxides of nitrogen being formed.

Action on metals: When activitated nitrogen came in contact with melted sodium a great deal of yellow light was developed. The yellow D sodium line predominated in the spectrum. This yellow coloration was so vivid that it served as a convenient sensitive test for the presence of active nitrogen. In contact with the vapors of several other metals, chemical reaction took place accompanied by light. A fresh surface of mercury was covered with a coating of nitride which was apt to be explosive but there was no reaction at the clean cold surfaces of other metals.

Action on compounds: Moisture and carbon monoxide like hydrogen served merely to dilute the glow. On the other hand ammonia, like oxygen, caused the extinction of the light. Oxides of manganese and copper had a similar effect. When metallic salts which vaporize fairly readily, such as halogen compounds of tin, mercury and copper, were exposed to the afterglow, spectra were produced, characteristic of compounds like mercuric iodide, which are decomposed in the flame. Cyanogen gave a lilac color and characteristic spectrum.

Most of the hydrocarbons and some of their substituted products form hydrocyanic acid or nitriles with active nitrogen. Nitric oxide had a very interesting reaction. A greenish, continuous spectrum flame was produced. On cooling to 180° a dark blue substance condensed which melted on removing the liquid air to an indigo blue liquid. This in turn evaporated to an orange colored gas (NO_2) soluble in an hydroxide. On weighing, the condensed product showed that as high as 2.5 per cent of the nitrogen had been activated and had reacted probably according to the equation, $2NO + N\ (act) = NO_2 + N_2$.

After the publication of these results several Germans, especially Tiede and Domeke in 1913, objected to the idea of an active modification of nitrogen. They claimed that there was always present in Strutt's nitrogen traces of oxygen which were responsible for the reactions noted. Strutt had taken a great deal of pains with his nitrogen but there remained the possibility that there were present traces of oxygen. With the assistance of H. B. Baker he then took especial care to eliminate all the oxygen and although the afterglow was somewhat weakened it still persisted. The Germans were not willing to accept these results so it was arranged, not very long before the war broke out, for them all to get together in London and thresh the whole matter out. The results were published in 1914 by all four simultaneously in *Nature* and in the *Berichte* vindicating the claims of Strutt that an afterglow could be obtained without the presence of oxygen. However, very minute traces of oxygen were found to increase the amount of luminosity. A little later Strutt published another article in which he showed that a number of gases could be used to catalize this formation of active nitrogen. Oxygen, hydrogen, sulfur, chlorine, many carbon compounds and hydrogen at a concentration of about 0.1 per cent gave a very good yield while methane in traces corresponding to 0.003 per cent gave a distinct effect.

The mechanism of the catalytic action has been explained by Strutt on the basis of certain observations of J. J. Thomson made on positive rays. If in a tube built for a vacuum discharge, a fine hole is bored through the cathode or negative electrode, then some of the positive ions will pass right through this hole and by means of magnetic and electrostatic fields can be caused to deviate so that the substances which carry the charges can be analyzed in a very beautiful manner. Some few of the positive ions are capable of not only losing their charge but also of picking up negative charges. Such substances are oxygen, hydrogen, carbon, sulfur and chlorine, all of which Strutt has found to be helpful in increasing the yield of active nitrogen. Therefore Strutt thought that it may be these negatively charged atoms which, by collision, were especially effective in activating nitrogen.

More recently another active form of nitrogen has been discovered by Mr. A. C. Grubb, working with Dr. G. L. Wendt at the University of Chicago, using an alternating corona discharge tube devised by Mr. K. B. M. McEachron of Purdue University.

A platinum wire is inserted in the middle of an ordinary Liebig condenser which is connected with one terminal of a high voltage transformer. The jacket of the condenser is filled with a conducting solution and is connected with the other terminal of the transformer, which is also grounded to reduce the danger. The glass wall of the inner tube serves as dielectric and as the solution keeps the dielectric cool the danger of puncturing it is lessened sufficiently so that a high enough voltage can be applied to fill the gas space with a gorgeous corona discharge. The activated nitrogen obtained in this way is more active than that variety studied by Strutt. It readily reacts with cold alkali metals while the other reacts only with heated metals. This newer variety reacts with cadmium, magnesium, aluminum and iron at far lower temperatures than does the other form. With ordinary oxygen it forms nitric acid, while with hydrogen, ammonia is produced. These reactions were not carried out with Strutt's nitrogen. On subjecting nitrogen to continuous discharge as high as 4 per cent of the active form is produced. It possesses also an odor somewhat like iodoform. The discoverers give to it the name of "nizone."

It is doubtless due to some such activated nitrogen that oxidation of nitrogen occurs in the silent discharge. The question of the commercial production of nitric acid in the silent discharge at ordinary temperatures is being investigated at the Engineering Experiment Station of Purdue University and sufficiently promising results have been secured to warrant studying the whole question quite thoroughly. In the fixation of nitrogen the most important phase of the problem is to obtain the activation of the nitrogen. It is not necessary to activate the nitrogen to the extent that either the Strutt or the Grubb nitrogen is activated because there is present in air while in the discharge fairly large amounts of oxygen more active than ordinary oxygen. There are apparently several steps in the activation of nitrogen. In addition to the ordinary, extraordinarily inert molecular nitrogen in various types of discharge, there are formed: the nitrogen studied so extensively by R. J. Strutt, that more recent discovery of Grubb and Wendt, and also probably atomic and most certainly ionic nitrogen. The ions, according to J. J. Thomson, are positively charged atoms and molecules.

The study of activated nitrogen is a very important one both for theoretical reasons and for practical purposes. When we understand just what limitations are placed upon the activa-

tion of nitrogen by the structure of its molecule we shall be in a position to know what will be the best methods to employ in its commercial fixation and just what efficiencies to expect in practice. A great deal of research is being carried out in this country as well as abroad and there is a very keen competition as to who shall make the greatest contribution to our knowledge in this most important field of chemical endeavor.

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ASPHALT IN THE UNITED STATES, A GREAT UNDEVELOPED RESOURCE.

Few mineral deposits in America are more promising to the prospector or more interesting to the scientist than the asphalt deposits of California, Kentucky, and the Rocky Mountain and Mid-Continent States, according to a report just issued by the United States Geological Survey, Department of the Interior. There are no deposits in the United States equal in size and purity to the mysterious pitch lake of Trinidad, from which asphalt has been taken for paving the famous thoroughfares of the world for many years without materially lowering its surface, but there is a great quantity of bituminous rock that could be used locally in surfacing our vast mileage of unimproved highways. Native asphalt, although one of our great undeveloped natural resources, has not been extensively mined because of the former abundance of asphaltic petroleum and because of our large imports, but now bituminous products of many varieties obtained from domestic deposits could adequately supply the requirements in several parts of the country.

As asphalt is formed from petroleum and is a remarkable preservative, it has long been a subject of absorbing interest to the oil geologist and the paleontologist. Many of the surface deposits throughout the country, like that near Los Angeles, Calif., which yielded remains of the extinct saber-toothed tiger, were formed in recent or Pleistocene time, but some are much older. The asphalt formations range in thickness from a few inches to many feet, and as they are associated with petroleum both geographically and stratigraphically and are of like origin and composition, they may be roughly assigned to the same fields.

PHYSICAL TESTS.

By Marion D. Weston, Ph. D.

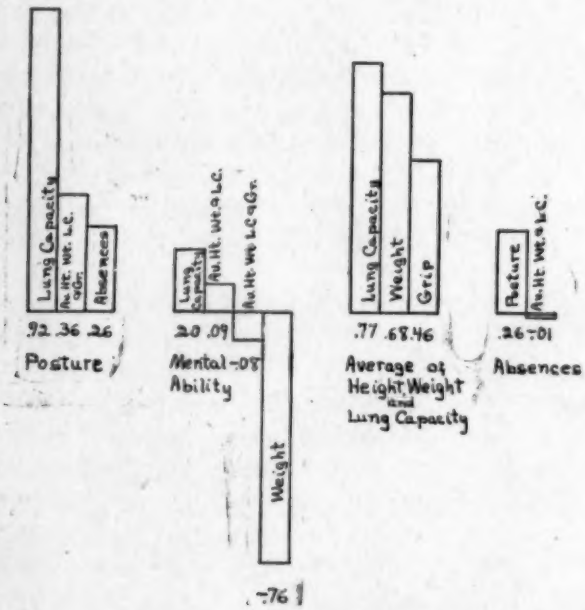
Rhode Island College of Education, Providence.

Physical tests are often given to pupils entering secondary schools and colleges, for the purpose of determining defects which may be remedied by suitable gymnastic work. Frequently no attempt is made to compare the pupil's record with any standard. As a result even if the pupil receives his record he has no means of knowing whether he is above or below others of his age and height. Physical measurements, such as height, weight, lung capacity and strength of grip, are far less frequently taken in elementary schools, where their need is, if anything, greater. These tests aim to discover deviation from the normal or standard and to help pupils improve themselves. The mere statement of what a child should weigh and what he does weigh placed in his own hands and also sent to his parents is a step in the right direction. Suggestions for increasing weight, in case he is underweight, will meet with respectful attention and frequently earnest effort to follow directions, for the desire for physical perfection is fortunately very keen in most human beings.

The problem of finding adequate figures for comparison is a very serious one. I have been able to get hold of only one set which gives lung capacity and strength of grip as well as height and weight. The fact that more have not been worked out proves that very little importance is being attached to comparisons with averages. The abundance of standards for mental tests is in marked contrast to the condition met with in physical tests and measurements. Possibly an even more serious difficulty is the lack of proof as to the real significance of the various measurements, the relative importance of the different tests. Which test gives the best index of general physical well-being? Is there any relationship between physical and mental ability? Correlations which may throw some light on these questions have been worked out by the writer from the figures obtained from a survey of grades I–VIII in a Rhode Island school during the year 1919.

Five tests were included in the survey: height, weight, lung capacity and strength of grip of right and left hands. Lung capacity was taken with a spirometer with scale reading in cubic inches; strength of grip with hand dynamometer reading pres-

sure in pounds. By lung capacity is meant the amount of air which can be expelled from the lungs after a deep breath has been taken in; by strength of grip the amount of pressure which the muscles of the arm enable the hand to bring to bear on the dynamometer. As the effort to make a good record makes a decided difference in some of the physical measurements, the examiners endeavored to give each child the same amount of encouragement, such as the direction, "stand up straight and tall." Demonstrations of spirometer and dynamometer were always made. Considerable explanation was frequently necessary with the younger children before satisfactory results could be secured.



The figures obtained were compared with the averages published by Dr. Thomas D. Wood, Teachers College, Columbia University. As a convenient way of expressing a child's relation to his own average, the individual child's record in each of the five measurements was divided by the average, found by Dr. Wood, for a child of his sex, age and height. The five decimals thus obtained were averaged, giving a figure which may be considered to represent his physical standing. Remedial work with the children found decidedly below average in lung capacity and weight is now being carried on by the school. The children have also been given posture tests by Miss Edith Haight, making possible correlations between posture and other

physical measurements. Records of absences for the second semester, 1918-1919, were obtained with the idea that attendance indicates to a certain extent the general health of the pupil, the reason for absence generally being personal illness. This assumption is doubtless safer with young children than with pupils of high school age who may be detained at home for household duties.

Correlations with mental ability were made possible by a survey of the same school with thirteen standard tests of intelligence and efficiency, made by Dr. Grace E. Bird during the year 1919.

The suspicion that strength of grip has little connection with the other physical measurements was corroborated by the correlation .59 between lung capacity and the average of height, weight, lung capacity and grip as compared with the correlation .77 between lung capacity and the same average minus grip. As strength of grip probably depends entirely on the customary occupation of the individual, it is easily conceivable that a person with poor records in this one respect may rank high in the other measurements. One remarkably high grip record was explained by the fact that the child sold newspapers. The same amount of time spent out of doors in active play would probably yield as satisfactory lung capacity but far lower grip records. In the comparison of the average of height, weight and lung capacity with grip the correlation was found to be .46, showing the relationship to be small. Although the dynamometer test is a favorite with children and young people alike and doubtless registers a wholesome tendency, it does not seem to be sufficiently important to warrant much attention as an indication of general health.

The correlation .77 between the average of height, weight, lung capacity and lung capacity as compared with .68 between the same average and weight suggests that lung capacity records agree a trifle more closely with the average than is the case with weight. The difference, however, is so slight that probably either measurement may be taken as a fair index of the child's general health. Weight is more often used. The Child Health Organization urges that scales be placed in every school building and that a child's weight record with his standard should be sent home each month. Since scales are so common in stores and other public places and spirometers are rare it is best to emphasize weight records although, according to these figures, lung capacity seems to be a trifle more significant.

Lung capacity also correlates very high with posture, .92. The relationship is no closer, however, than would be expected from the effect good posture is known to have on the size of the thoracic cavity, which in turn controls the space occupied by the lungs. It is probable that better general health as well as greater immunity from respiratory diseases will accompany improvement in lung capacity, but I know of no figures to offer in proof. A partial experiment was made with a group of normal school students in the spring of 1919. Freedom from severe colds seemed to be rather more general among the girls who were above the average in lung capacity. No correlations were worked out. Since the many advantages, both mental and physical, claimed for correct posture are probably in the main true and since, as will be shown later, there is some correlation between lung capacity and mental ability, there seems every reason to stress both posture and lung capacity. Both are easily improved by young people with a little conscious effort, which will yield immeasurably large returns. There is no greater incentive to improvement than frequent measurements to prove that results are really being obtained. It would seem that the correlation between lung capacity and posture is so high that repeated tests of both are unnecessary. A good posture test, which can be given without apparatus and to a considerable group, may be substituted for the lung capacity measurements which cannot easily be taken without a spirometer and must be given individually. Another measurement, which would probably answer the purpose, is girth of chest. The tape measure alone is necessary for this test. The necessity for individual work and the added amount of time involved make this measurement less desirable than the posture. No figures were collected on this particular measurement. There is a suggestion of relationship between the average of height, weight, lung capacity, grip and posture as shown by the correlation .36. Record of attendance compared with posture gives the correlation .26 as compared with .01 between average height, weight, lung capacity and attendance. If constant attendance is evidence of good health or at least resistance to disease, as it seems safe to assume, then apparently more can be told about a child's health from his posture than from the average of his other physical measurements.

A conspicuous lack of correlation between physical and mental ability is apparently shown by the three comparisons: lung

capacity and mental .20; average height, weight, lung capacity, grip and mental .—08; weight and mental .—76. The last mentioned is so very low that it almost suggests that underweight might compare more favorably. The question of malnutrition is of such vital importance in children's health that this correlation is particularly surprising. With adults, where overweight, at least after 35, is a more serious condition than underweight, the problem is different. The close relationship between lung capacity and mental ability suggested by Dr. Stuart Courtis, although not confirmed by the low correlation .20, is partially supported by the fact that this correlation is positive, whereas the comparison with average of height, weight and lung capacity and also with weight alone gave negative results. It would seem, therefore, that the relationship between lung capacity and mental ability is closer than with the other physical measurements. It is possible that better results would be obtained with adults where the factor of rapid growth would not enter in to divert energy from mental work. This may be a different question from the one partially answered by the correlation .20 which is a comparison of conditions in different children rather than a series of records from one group. To attempt to answer this question would involve an entirely different and far more difficult experiment. External factors here, as in all experiments with health conditions, are very difficult to control. The group tested should be consciously striving to improve lung capacity but should not know that any special significance is being attached to the mental tests, which should come in as a part of the regular school work.

This work with physical tests, though crude, has proved suggestive. No claim to refinement of method is claimed for the experiments. Variability for age was considered only in terms of sex and height. Although other factors should doubtless be taken into account, with the present lack of standards for comparison this was not possible. Of course, the number of cases is too small to make any results conclusive. The following conclusions are offered with these limitations in mind.

1. Muscular strength, as indicated by grip measurements, does not necessarily mean good general health. There seems to be little relationship with other physical measurements.

2. Weight correlates well with the average of the physical records. It is probably a very significant measurement for children.

3. Lung capacity is apparently the most significant record from both physical and mental standpoints. Since the correlation with posture is very high, it is probable that the latter test may be substituted for the spirometer readings.

4. With the single exception of lung capacity no connection between mental and physical ability is indicated by these correlations.

Table showing range, median and quartile deviation:

Measurement.	Range.	Median.	Quartile Deviation.
Weight	.75-1.47	1.05	.05
Lung Capacity	.51-1.30	1.98	.08
Average of grip of right and left hands	.72-1.49	1.02	.06
Average of height, weight, and lung capacity	.79-1.24	1.01	.05
Average of height, weight, lung capacity and grip	.77-1.32	1.02	.06

The median was found by the rough formula $n+1/2$ without correction.

The Quartile Deviation was found by Yule's formula: $Q=(Q_3-Q_1)/2$.

CORRELATIONS.

Posture and lung capacity	.92	125 case
Average height, weight, lung capacity and lung capacity	.77	218 case
Average height, weight, lung capacity and weight	.68	101 case
Average height, weight, lung capacity, grip and lung capacity	.59	218 case
Average height, weight, lung capacity and grip	.46	218 case
Average height, weight, lung capacity, grip and posture	.36	111 case
Absences and posture	.26	111 case
Lung capacity and mental ability	.20	55 case
Average height, weight, lung capacity and mental ability	.09	55 case
Average height, weight, lung capacity and absences	−.01	109 case
Average height, weight, lung capacity, grip and mental ability	−.08	55 case
Weight and mental ability	−.76	55 case

The correlation formula $\dfrac{1-\Sigma d^2}{n(n^2-1)/6}$ was used. The cases were arranged in order of merit regardless of grade because each child's record was being compared not with an absolute standard but with an average taking into account sex, age and height.

THE USE OF PHYSICAL EQUIPMENT OF THE SCHOOL BUILDING IN CLASSROOM INSTRUCTION.[1]

By Dean E. S. Keene,

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When the United States entered the war, much occurred to show that we have entered into a new period of living. Men went to schools, the like of which had never before been a part of our educational system. Our armies learned things with fewer textbooks than were ever before provided for learners. Civilians began to acquire a new knowledge. They are still learning.

During the summer just past, this change was expressed in a most remarkable manner. At a live stock sale in western Minnesota a Holstein bull, Sir Pieterje Ormsby Mercedes 41st, sold at auction for $65,000. A few weeks later a Guernsey bull in Texas sold for $62,000. These are not the highest prices paid for such animals. In New York, somewhat earlier in the year, a Holstein bull, Rag Apple the Great, sold for $125,000. When such sums of money are paid for the means of propagating milk-producing stock, these incidents are sufficient to cause us to wonder at the change in the milk man. He used to appear in the morning with a big can, in a little covered wagon, smelling of unventilated barns, and announce his presence with a bell. His milk was universally sold at 5 cents a quart. Its quality was unknown. His customers knew nothing about it. It was just milk. Today we have in the place of this happy-go-lucky milk man, a milk producing company, regulated in all its branches by methods that are quite scientific. The old-time little business has been transformed into an industry. It affects every one of us and enters intimately into our lives. Milk is now known to be, not only a food that contributes to our contentment, that has to do with the comfort of the sick, the well-being of the convalescent and the lives of our babies, but also that one infected dairy may produce an epidemic of disease. Instead of any old milk, we demand pure milk.

Milk production, in those states that are sufficiently advanced in intelligence, is regulated by law and safeguarded by dairy commissioners. The laws are administered by milk inspectors. Tested cows that measure up to definite standard are recognized by all herdsmen. The cow as viewed by the dairyman, is a milk machine that must come up to a standard of efficiency or be

[1]Read before Section on General Science of the C. A. S. & M. T., at Lake View High School, Chicago, Nov. 28, 1919.

replaced. Milk must contain a minimum of butter fat. Butter must contain a minimum of water. Terms such as pasteurized milk, certified milk, Babcock test, cream separators, legal butter, processed butter mulsifiers and others that designate certain scientific standards, processes, and machines have to do with the operation of the milk industry. Ought we know about milk, its production, its preparation, distribution and purity? If so, when and where will it be taught, or is this information to be given alone in agricultural schools?

The milk industry is an example of the change that has taken place in practically all that affects domestic and business affairs. New methods of manufacture, improved ways of doing things, the application of new processes, unheard of demands, all seemed to focus and break out with the war.

New conditions of industry bring changed conditions of living; immediately then, a demand for better homes. This is not really a new demand, it is quite old in fact and has only been stimulated by the effect of the war.

The demand for better and more comfortable homes has been going on for years and has been the stimulus for the development of household machinery to a point such that the most modest cottage may be not only comfortable but possess the conveniences of water supply, heat, and light that were formerly accorded the few.

With this complication of domestic mechanism, that may seem to have suddenly descended upon us, there has come the necessity of keeping it in working order. In the past year, as never before, repair bills that formerly were modest, have assumed proportions that are startling. Not alone in repair bills but in the making of minor adjustments or the correction of slight disarrangements, many householders have been shown the advantage of a knowledge of household mechanics. When a woman watched a plumber replace a damaged filler-ball in a water tap at the cost of $4.50, she suddenly awakened to one means of reducing the high cost of living.

Of the things of prime importance, homes should come first of all and of a right should receive first consideration. The mechanism of homes should claim the attention of the schools. It is evident to those who teach such subjects that all applied science cannot be included in general courses of study. It is equally evident that some information should be given of mechanism and principles of operation included in household machinery.

The average science teacher is not familiar with domestic engineering, neither as to the functions of the machinery nor their method of operation. This, however, ought not deter an attempt at presenting a subject in which may be requisitioned the services of the school janitor, the fireman, the contractor, the plumber, the architect and anyone else who is in a position to help. The war taught us the value of such teachers. Much information may be imparted without textbooks.

Our laws have in many respects kept apace with industrial developments and in those states that have the most aggressive and the best guiding influence there has come legislation regulating the sale and use of solid, liquid, and gaseous fuels, electricity, water, weights and measures, and all else that has to do with the interest of the people. In this respect it is a matter of pride that Wisconsin and Illinois are among the foremost in formulating regulations that have served as guides for other states in conducting their affairs for the best interest of their citizens. All such laws and regulations are to be had free of charge by addressing the proper departments of the state. Summons of such regulations are easily made for presentation and become valuable information in every day life.

A comfortable home is the most desirable possession in family life. It is true that—"Be it ever so humble there is no place like home"; today as never before the home may be humble and comfortable at the same time. The comfort contributed by household conveniences are too well recognized to require discussion. Their mechanical perfection and adaptability are such as to make possible the complete equipment of any type of house and to suit any community. A knowledge of the various forms of domestic appliances, their mechanical construction and principles of operation contributed much to the general welfare of those who use them.

Every normal man and woman looks forward to the possession of a home. When the time arrives, the construction of the house involves many problems that have been considered only superficially or not at all. The result is much worry, anxiety, and often unnecessary expense with frequent unsatisfactory results because of a lack of information that ought to be common knowledge.

Suppose that a home is to be constructed anywhere outside of the corporate limits of a town and away from electric supply. It is to be provided with the usual conveniences. The house-

holder must consider in addition to the erection of the house, methods of heating, lighting, water supply, and sewage disposal. Aside from these he may consider many other items of secondary importance. If the house is to be built in a city, where a sewer system, water, and lights are available, the process involves consideration as to heating and plumbing, but away from the common sanitary facilities the difficulties are increased directly as their number.

The house is to be furnace-heated. The first question that comes to the owner is—what method of heating will be employed? Will it be a hot-water or a hot-air plant? This is often decided by advice of a friend, the architect or because of some personal experience, or knowledge of a house that seemed to be satisfactorily heated. It is quite unusual that the newlyweds know anything of household affairs. House heating having no place in the curriculum of the average school or college, it is rare that anything is known of house heating plants.

Suppose it is decided to heat the house with a hot-water plant. Now that the style is to be chosen, what type of hot-water plant is to be installed? Will it be a simple gravity system or a pressure system, for each of these have particular advantages that are worthy of consideration. If the hot-air plant has been chosen—the owner will be interested to know the most approved mechanical construction in choosing between various designs. He should understand the possibility of humidification in the hot-air plant. He should understand the mechanical construction of the furnace both as to the possibilities of repairs and the liability of gas leakage. At least he should know the elements of a well constructed heater.

Unless the various general features of a heating plant have been brought to his attention, he will probably not be aware of the methods of adapting a furnace to a building, nor its limitations. He does not comprehend excellence in workmanship or faulty construction and further it is likely that he does not understand the delivery of air to the various parts of the building, its gravitational flow, the size of conduits, and it is not at all likely that he knows anything of the physical properties of air.

Possibly the hot-air furnace man has talked well of the advantages of desirable atmospheric humidity that may be obtained with a hot-air plant and the advocate of a hot-water heating plant has told him of the deleterious effect of the dry air of such a

furnace, all of which is beyond his comprehension. With so much accessible material with which to illustrate, it is not at all difficult to point out the working principles of house heating.

The possibilities and limitations of steam as a heating agent is a convenient means of introducing the general subject of heating. The school heating plant furnishes an extensive laboratory of applied physics. The furnace, in the study of combustion, combined with the boiler furnishes the best possible example of heat generator. Such a plant may be made to show the relative commercial value of fuels. Its working principle is that of the heat of vaporization. The heating effect is produced by condensation. The heat distribution illustrates convection. It furnishes an excellent example of specific heat, the relative temperature and pressure of steam, and practically all of the laws of heat. The first principle of steam heating to be impressed on the learner is that the temperature of steam is of minor importance, that the heat of condensation supplies the heat in its radiator. Atmosphere humidity is a topic that has a place in every work on elementary physics and yet in its application there are few subjects so little understood. Imagine a highly educated person, one whose word is taken unquestioned by his friends, condemning a hot-air heating plant as objectionable, because of the "dryness of its heat," and emphatically stating that, "hot-water heat is much to be preferred because it gives a more humid atmosphere." Atmosphere humidity should be understood both because of its indoor effects and the difficulty of its maintenance, as well as the general atmospheric conditions that influence every season and all outdoor life. Most of us have been warned against breathing "night air"—as though there was some other form of air at night.

Most of the modern school heating plants are provided with air conditioning apparatus in which both relative and absolute humidity maybe and usually is beautifully illustrated.

In the mechanical construction of the boiler and its necessary accessories is illustrated the pressure gauge and safety valve and with their use the application of absolute pressure and gauge pressure. It affords examples of the various forms of cock and valves that are universally used for the control of water, steam and gas, and provides means for the study of their mechanical construction and care. The feed-water pump furnishes an illustration of a form of steam engine combined with a water pump and illustrated in the difficulty of pumping hot water—

the principle of low-pressure vaporization. If the heating system happens to be of the vacuum type, the opportunities for the study of the properties of steam are greatly increased. Once there is made an acquaintance with the heating plant and the student is required to report on the various functions of the accessories and the working principle of the entire plant, the subject becomes at once alive with interest.

Temperature regulation has come to be a recognized part of every form of a school heating system. Temperature regulators are made in two general types, the electric thermostat and the pneumatic thermostat. Each has its particular field of usefulness. The electric thermostat is the type best suited for the household. It is manufactured under various patents, each of which accomplished the same functions in some difference of manner. A general knowledge of its construction and mode of attachment to the furnace; a little instruction as to the limits of its usefulness, and the thermostat is the most faithful mechanical servant. Without this information it may do exactly the reverse of its desired function and require the services of an expert.

The pneumatic thermostat is the heat regulator that is used in large buildings when each room is to be separately controlled. Its mechanism is quite different from the electric type but its principles and operation are no more difficult to conprehend.

The temperature of school rooms is today very generally controlled by pneumatic regulators. Such a system provides, not only an illustration of heat regulating apparatus but shows the possibilities of compressed air as a means of transmitting work and power. It furnishes examples of motor valves both for radiators and for warm air registers by means of which a uniform temperature is maintained through thermostat control.

Every enterprising householder desires the advantages of running water in his home. It is today possible to provide a form of water supply under any condition of habitation. It may be power operated, and entirely automatic in its action; or it may be simple force pump and tank. The market provides facilities to suit any condition of operation. The ones interested may select among many forms of machinery, suited to the condition of use. It is a question of intelligent application of ready made things that are best suited for a desired purpose. Water supply, in connection with sewage disposal, is the most important —except heating—of all problems of house building.

Water has to do with every domestic service, it enters into everything connected with life. On its purity depends the health of the family and its convenient distribution contributed to the contentment of each of its members. Unlimited hot water is an unlimited blessing. Water and its use is certainly worthy of more attention than has been given as to its quality and the machinery required in domestic service.

While city schools do not furnish in their water fixtures examples of domestic water supply, they do provide all of the fixtures, valves, cocks and other appliances used in domestic water distribution. Many consolidated schools are provided with examples of perfect domestic water supply plants. All such buildings furnish means for the study of plumbing systems.

It is not expected that the future householder is to become a plumber nor a sanitary engineer but the most superficial acquaintance with the mechanics of water supply apparatus will be a very helpful guide to the builder of a home, and a slight knowledge of the general qualities of water, its purification, its softening and the means of guarding it from pollution is well worthy of more than passing attention. It is certainly worth while to know the various systems of domestic water supply that are used in private plants; the method of safe-guarding a good well from surface pollution, and the present day devices for softening water.

In the study of mechanics, power generation should have a place at least as instructive as a manufacturer's catalog. The present-day small electric generator has made possible the utilization of power of small streams that heretofore could not be made available; the hydraulic ram does most excellent service as a pumping engine in the neighborhood of a suitable stream and its use in connection with the pressure tanks makes an admirable as well as an inexpensive system of water supply. Apparatus of this kind may be obtained ready for installation. In many instances natural water power sites, suitable in size for a family, may be installed at nominal expense. It is this practical feature that should be brought to the attention of learners. While school buildings provide examples of this type of power generation they may be discussed in connection with the engines that form a part of the mechanical equipment.

Sewage disposal has come to be so generally recognized as to require no argument in its favor. The type of private sewage disposal plant for a definite purpose is today only the necessary

mechanical arrangement to suit the place of its installation. The septic tank, either of itself or in combination with an anaerobic filter is successfully used as a means of a private sewage disposal under almost any topographical conditions. It is successfully used even in flat areas where effluent must be taken up entirely by the earth in the immediate vicinity. The principles of the septic tank, its construction and operation, are well within the range of the average intelligence, and may with profit be taught in connection with natural science. It ought not be necessary that people who are supposed to be scientifically educated should be required to ask as to the possibility of disposing of sewage.

Many consolidated schools dispose of their sewage through such plants. In any case the school supplies examples of plumbing that is a part of sewage disposal system and provides material for the study of a great variety of fittings, pipings, fixtures, traps, vents, flush tanks, closet seats, schemes of plumbing and all else that has to do with its sewage up to the means of final disposal. These may all be examined in detail and under working conditions.

The ever increasing cost of fuel—which has now reached a point sufficiently high to be viewed with alarm—shows no tendency to decrease. What does the average person know of fuel values? Even in favored localities where fuel is plentiful the price is sufficiently high to cause concern, and in the more remote localities in a cold climate the cost of heat is viewed with the gravest consideration.

So little attention has been given to relative fuel values that practically none but engineers are acquainted with the measurement of heat. Even scientists who are accustomed to heat calculations, in chemistry, physics, and other branches, are lost when quantity of heat is mentioned in B. t. u's, the common standard of its measurement. All contracts for fuel in the United States are based on the British thermal unit. All heating values of gases, fuel oils, and other forms of heat generators are rated on the same commercial basis. The law of this state says that, "coal-gas shall have a heating value of 600 B. t. u.'s, per cubic foot," and most people have not the remotest idea of its meaning. It is remarkably strange that every science, even home economics, expresses heat in calories and all industry bases fuel values in British thermal units.

It is of little consequence which is the better measure; common

custom is in favor of the established unit and should be used until custom changes. The point in question is this, when fuel is bought at the present price, what kind gives the greatest quantity of heat for a dollar? Where fuel-gas sells for a high price, is coal at the prevailing price a more economical fuel? Which gives the greater quantity of heat for the price, coal or gasoline? Kerosene or coal gas?

The heating value of coals is influenced very largely by the moisture and ash that are present. These factors may be readily determined without the apparatus of a scientific laboratory. Many school heating plants keep a regular log of the rate of evaporation in pounds of water evaporated per pound of coal burned. Much may be learned from an intelligent fireman as to the value of fuel, the quantity of fuel required to heat the building, the method of firing, the type of fire to produce the best results and the general information to be derived from acquaintance with heat generating apparatus. Fuel values are based on factors that are readily determined and not difficult of comprehension, their calculations are simple arithmetic. Coal is being sold by thousands of tons, at unheard-of prices, and the buyers take what is sent because the people do not know the heat value of fuel. In many cases coal sells today at $10 to $12 per ton which may and often does contain as high as 25 per cent of water and ash, a very high price for non-combustible material aside from the loss of heat contained in good coal.

The ventilation of houses is best understood from the investigation of the effects produced by the ventilation engineer. In his discussion, Mr. Lewis refers to the practice of ventilation as an art but much that has to do with ventilation is science. The scientific principles that are applied in ventilation should be made the subject of systematic study. The measurement of air, and its physical properties are effected by heat and moisture. The introduction and exit of air from inclosed spaces both by gravitational and by mechanical means all reach their highest perfection in school buildings. All these are topics that are touched upon in physics but usually they are not presented as actual working problems. The measurement of the air that enters this room through the ventilation system may become a problem of rare interest as well as a means of fixing upon the student's mind the quantity of air that is taken as a ventilation standard. Atmospheric humidity may just as well become a real problem where relative humidity and absolute humidity are

not mere physical terms but features of air conditioning. A knowledge of such apparatus as the Hygrodeik, with which humidity is determined mechanically from reading the wet-bulb and dry-bulb thermometers, as well as the Weather Bureau Hygrometer with a humidity table, contributes much toward an understanding of atmospheric conditions. The process of air humidification, as affected by the mechanical method of ventilation, is one of the most instructive means of explaining absolute humidity.

In his opening paragraph, Mr. Lewis said: "The art of ventilation has received much study—and there has developed a general practice concerning fundamental principles which should not be lost sight of." The art of ventilation applies most in this case to large buildings where mechanical means can be used to produce air in any desired quantity.

Aside from the general principles—that are not difficult to comprehend—the practice of ventilation is the mechanism used by engineers in ventilation systems. It should be the business of teachers to know the simple principles used in such plants as may be available. It is evident that there are differences of opinion among those who are best informed as to the most efficient practice in applying the principles that are fundamental. The teachers' business is to know to what extent these fundamental principles are applied. In case of different systems, as air-conditioning plants, the teachers should be in a position to point out the object each is intended to attain and in some degree to apply such tests in determining their efficiency.

The use of the anemometer in measuring the air supplied to a school room is one that always arouses student interest and leads to discussions that are most profitable.

The electric fixtures of a school building ought to supply the commercial elements of electricity that are not contained in textbooks. At least one section of each school building should be so wired that the system of distribution will be exposed to view. The switch-board, which in most school buildings is sacred, and to be approached only by the man in charge, is a thing full of valuable information. It expresses the various circuits of the buildings, the reason for which requires explanation. The switches, fuses, and above all, the meter are features of electric practice that deserve close attention.

The modern school house possesses, of course, a complete system of electric wiring, for lighting, for bell system, and for the

program clock and frequently inter-communicating telephones, often generators, motors, transformers or motor generators. Each of these is in itself a course of study. The watt-meter should be a regular part of the physics laboratory. All bills for electricity should be checked by the students. Few modern schools are without a storage battery, the daily performance of which is of the greatest interest and value to learners. Its care, charging and maintenance should be common knowledge. The commercial application of electrical appliances is that part of the subject which in schools often receives scant attention. A duplicate of each receptacle, branch, block, cutout, switch, circuit, breaker or other fixture is each worthy of the closest inspection and consideration. The office of each piece may well be a part of the student's report with an explanation of the part it intended to perform, likewise each heater, light, motor, generator, transformer or battery may well receive attention as to general conditions of operation. It is not so much of im-importance to know the chemistry of a storage battery as to know how it is charged. These in schools should be a part of each student's course to inspect, analyze, to care for or to operate for a certain time, under the person in charge. If it is the janitor's business to care for the clock system, the janitor may become an instructor to explain his method of caring for the necessary apparatus.

Each part of the school equipment may become a part of the teaching apparatus with each attendant an instructor to the extent of his duties, each student to receive as much time and attention as circumstances will permit.

No human being can be expected to know intimately all that is applied in scientific nature in a modern school building. The director of such a course should then summon to his aid those who are best equipped to explain these matters. The student should report in his notebook as much as possible of the things presented. The important features of this subject is to acquire a general understanding of the subjects presented, then should occasion demand an intimate knowledge of any feature, he will have a foundation on which to build. More than this cannot be expected in any but a technical school.

GYPSUM IN 1919.

According to a preliminary estimate by the United States Geological Survey, Department of the Interior, 2,451,000 short tons of gypsum, valued at $16,000,000, were sold in 1919. This is an increase of 393,985 tons and of $4,529,146 compared with the sales in 1918.

THE PROJECT AS A METHOD OF TEACHING.

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I. Introductory Statement.

The project as a method of teaching implies that the teaching units provided for instruction purposes grow out of the use of projects. It does not imply, however, that teaching by use of projects precludes or excludes the use of other methods. Teaching by projects is a phrase not uniformly interpreted; in fact, there are many types of interpretation and of usage. Among these varying usages of the expression two important conceptions seem to have been derived:

1. To regard the project, whatever it is, as fundamental or basal in any teaching exercise, that is, it becomes the central and controlling means of carrying on units of instruction.

2. To regard the project as supplementary or applicative in nature, that is, it becomes the means of making specific application of principles supposed to be known whether that knowledge comes by way of memory or by way of reason.

In either case, the project is a means of vitalizing instruction. It is dynamic, impelling toward a completed unity of activity which the mind conceives. Whichever of the above conceptions of the project is accepted, self-activity is paramount; that is, first-hand experience in a real life situation, where the elements of the activity appear in their natural setting, is imperative. If not all types, certainly vocational types of education would demand this kind of first-hand experience.

II. What is a Project?

As indicated above, there are many varieties of interpretation of the meaning of project. Like many new terms, it has been used frequently with little discrimination; it has been identified: (1) With problem; or (2) with laboratory exercise, as in the application of the principles of physics to the mechanics of the phonograph; or (3) with the intellectual problem that is peculiarly knotty; or (4) with a series of routine activities, such as answering the telephone, reading a telegram, interviewing a senator; glancing at the morning paper, called a day's project; or (5) with ordinary attempts to accomplish a purpose.

The commonly accepted psychological interpretation presents the project as a purposeful act. This notion taken alone is inadequate since it suggests that the term project is identical

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with that of problem, or purpose. This statement seems to ignore the sociological character of the project, thus limiting its scope as a method of teaching and really making the use of the term superfluous. The project as conceived in agriculture implies the purposeful act, but also puts emphasis upon the typical forms which the purposeful act has made objective and which the purposeful act continues to hold objective, since it represents a complete cycle of relationships. Subsequent considerations will make this criticism clearer.

May we regard then as a project any enterprise, however large or small, provided that in such enterprise no elements essential to its completeness, as it does or would exist in real life, are omitted. For school purpose then a home project is a unit of activity whose form and purpose are either identical or fundamentally similar to those of a like unit of activity in its natural setting.

III. What are the Standards of Teaching?

Before we can say what educational value the project presents in teaching method, we must state the principles by which the project method is to be measured. Skill in teaching demands at least six points:

1. Teaching should motivate the pupils; that is, the teaching must carry aims, purposes and problems which are accepted by the pupils as worth while.
2. The teaching must provide for pupil initiative; that is, opportunity for self expression should be conspicuous.
3. The teaching should provide also for pupil judgment; that is, the plan must permit choices on the part of pupil with reference to the purposes accepted, and with reference to the steps taken toward the realization of such purposes.
4. The teaching should provide for organization of thought on the part of the pupil; that is, responsibility for marshalling the facts in the direction of the purpose to be realized is primarily the pupil's.
5. Teaching must provide opportunity for use and application of the principles arrived at in the teaching exercise; that is, principles must be applied in order to be comprehended.
6. Teaching is essentially a program of discipline; that is, whatever may be the teaching exercise, it should train the pupils to think.

IV. How Does the Project Meet These Requirements?

1. *It furnishes a basis of motive and purpose.* The project

demands first of all self-activity. The word implies constructive self-activity. Whatever furnishes a basis of worth-while activity motivates and interests. The strong appeal which the project makes to boys and girls may be explained partially as follows:

(1) Nature has an abundance of energy to expend, which she releases most readily along race-old paths. The project activities furnish a strong appeal to these native tendencies, because of their multiple contacts in experience with the concrete and tangible things which are to be controlled and manipulated. Particularly at spring time there is a ready release of energy for these activities of the out-of-doors. The value of these channels of expression in motivating work will not be denied. The question may be raised whether the lessening of available energy by work and the appeals of new things may not reduce materially the peculiar educative value of the project as a method of teaching. The answer is that the project form of study would still remain significant.

(2) Competition and cooperation appear to protect the project against any such possible waning interest. Frequently these factors are the principal basis of completing a project. Nature has so endowed youth that even after an activity may seem to lose its value for itself, it is still pursued because of the social appeal which the activity implies. In other words, competition and cooperation are tendencies that can release energy even when it almost seems to be lacking. The project is an enterprise with such a social setting that the pupil may complete his work for sake of social approval or sanction. It is not necessary, however, to assume that native interest has entirely waned since the project is furnishing constant change of experience and new relationships to control.

(3) Promise of economic return adds strength to the motive power of the project. Many children leave school for economic returns. The project becomes a means of giving promise of economic return without the necessity of breaking with the school; at least it furnishes an opportunity for independent managerial activity which appeals to adolescent life.

2. *It provides for individual initiative.* One of the principal arguments for the project is the opportunity it furnishes for the expression of individual initiative. This position is tenable since:

(1) The project reflects the pupil's own desires. It is placed upon the pupil to select the project, helped by the counsel of the parent and teacher when needed to prevent serious mistakes.

(2) It recognizes individual differences. As children pass up from grade to grade the differences become more marked and therefore more recognizable. The project being an individual undertaking is selected therefore on the basis of the individuality of the pupil who is to manage and execute the work.

(3) The character of the project demands not alone an initial spurt, but a continuous expression of initiative; that is, it is an activity that demands constant direction by the pupil however well it may have been launched.

(4) The pupil is responsible for the project from the time that the selection is made until the final report is completed and accepted. This type of teaching bids fair to correct an evil in modern education which is growing with the accentuated emphasis upon expert knowledge, namely, dependence upon subject-matter experts for all responsibility in interpreting facts and principles.

3. *It provides for individual judgment.* No great amount of initiative will be expected to appear in a pupil if no credence is given to his judgment. Judgment develops in an individual only as he accepts opportunities for making choices. The project furnishes a constant exercise and testing of judgment:

(1) In the first place, the selection of a proper project is a real challenge to the judgment. The teacher and parent may offer counsel; in fact, they may lend much aid, but among many possibilities the pupil is to make his own selection. His selection of a particular type of project in agriculture would demand cognizance of the community needs which the project was to serve, of the farm on which it was carried out, of the facilities of school and the teacher for training, of the parents who were to supply equipment and counsel, and of many other factors which would be involved.

(2) A project which runs through a period of weeks and months involves the continuous use of judgment after the selection has been made. If he selects a poultry project, he must from time to time answer such questions as: What breed of chickens shall I handle? What incubator shall I use? When shall I start the incubator? as well as a host of other questions which continue to appear throughout the cycle of activity.

(3) The judgments are stated. A judgment that is stated finally in a social medium, whether that medium is a group of farmers, a class in school, or what not, becomes very significant educationally. Many judgments are made by pupils but be-

cause they are never checked they leave the judgment, after all, flabby and impotent. The decisions which the project boy or girl makes are always open for check by his fellows in the school and the community. In other words, the project furnishes tangible evidence of expressed judgments, which are checked formally in class work, informally in interested social groups.

4. *It supplies a real situation for the organization of thought on the part of the pupil.* Much, if not most, of our school work is broken up into fragments of study almost innumerable. This situation tends to break or lessen any demand for organization of thought on the part of the pupil, particularly since teaching is being done more and more by subject-matter experts.

With pressure for time in presenting this vast amount of culture materials, teachers tend to furnish pupils predigested educational pabulum; that is, teachers thinking that they can utilize more subject matter in this way, present their teaching material to the pupils in logical form, thereby developing in them an attitude of dependence and passive acceptance. This procedure gives little necessity for sustained attention. Quite in contrast with this, the project by virtue of the steps that are necessary to take in it, carries the pupil along from the more fundamental to the less fundamental or from the less fundamental to the more fundamental, giving him a rather definite and clear view of relationships involved. These relationships appearing in an actual enterprise become meaningful where abstract materials, however logical in presentation, would fail to secure response. The demand for the use of the imagination in project activity furnishes the most normal transition from thinking in the concrete to thinking in the abstract. The tangible connections are more stable because of the multiple associations that necessarily form in such an activity. The true basis of reasoning lies in the pupil's control of these tangible connections and not, as some try to imply, in the tangible things themselves. The pupil who might object to the logical outline of the teacher finds himself, together with the teacher, checked by the facts and principles that inhere in the concrete situations which the project involves. In the field of the abstract the differences of opinion may be so marked as to baffle the mind against any fruitful organization. The high school pupil might find genuine opportunity for organizing his mind in an attempt to follow selection through a cycle in animal breeding when an attempt at comprehending the theory of evolution would be

futile. The project provides an ideal setting for organizing first-hand experience and discovering its relationships in life.

5. *It implies fundamentally utility and application.* Teaching by means of the project begins in the thought of application. It is not a mere last step in instruction. It is rather not only the beginning and the end of instruction, but is its central purpose. Because utility and application are the central purpose of instruction, the four points already discussed are the more readily realized. Without the idea of utility and application, teaching becomes spurious and colorless. When the test of application is made to the project, the conception already stated—namely, that the project is basal and central in instruction, is fully substantiated; for the project that merely furnishes an opportunity for applying principles becomes incidental and loses much of its force as a means of controlling the factors of learning. It is in application that the two dominant conceptions of the project show their fundamental differences.

6. *The use of the project as a method of teaching implies a fundamental type of discipline.* The only true discipline is self-discipline, though agencies outside of one's self may point the way to self-discipline. An activity that provides genuine problems, places responsibility upon the individual for initiative, judgment, and organization of thought, and is dominated by its useful and applicative connections is an activity, par excellence, for discipline. In fact, it exalts the idea of real discipline, the kind that gets its meaning in the organization of one's facts with reference to an activity that is felt worth while and for which responsibility is definitely placed and accepted. The organization of the project reinforces such an idea of discipline, a discipline which the situation demands, and not a discipline of outer compulsion. There are at least three types of disciplinary factors involved in project working.

(1) It is an activity, first of all, in a natural setting. The pupil must conform to nature. Teachers may be wrong, but nature must be taken as she is. To violate the laws of nature, is to invite a type of check that cannot be gainsaid.

(2) It is an activity in a social environment, where the group stimulates, where the group then praises and blames. To disappoint the upholders of the sanctions of society is to invite embarrassment and chagrin.

(3) It is an activity in an individual mind that is very sensitive to its own integrity. Because the mind must give outward

expression constantly in the execution of a project—an expression that is always checked socially—this integrity is safeguarded by intensive thought. To become conscious of a lack of mental integrity is to undermine one's self-respect.

V. *May the project do even more?* In addition to meeting the standards of teaching which we have imposed, the project may do even more in making instruction dynamic.

1. It gives the pupil acquaintance with a new field of activity from which he may gain mental content for (1) general culture, (2) educational guidance, and (3) vocational guidance.

2. Since it is experience in a natural setting, it furnishes a comprehensive vantage ground for evaluating tool subjects which so often have little motivating power. A tool is never so much valued as when need for it is upon us.

3. Since it is an experience in a natural setting, it opens up new fields for thought, problems that have never been attacked even by mature investigators. Opportunity for discovery is the greatest incentive for study. Not all of its value is lost even if it is only a rediscovery.

4. Since it recognizes individual differences as they are recognized in human society it is a basis of stimulating all classes of pupils. It not only sets minimum standards upon which the dull may fall, but opens a competitive field in establishing maximum standards for all, however bright. It may be graded to suit different classes and may be graded to suit individuals in the class. It can be based upon the level of activity for the less mature, upon approbation where group life would affect it, upon economic return where money becomes an important issue, and upon other factors when found operating. It furnishes a stable basis of controlling the individuals upon whom many and variable demands rest in our modern, more or less, entangled society.

5. Since it puts some emphasis upon economic return, it provides a suggestion for meeting the demand of high school boys and girls for remunerative employment during school days, and gives economic significance to educational activities. It emphasizes managerial ability which is akin to genuine learning.

6. It supplies immediate connections for educating parents. How much the public school contributes directly to the education of adults through the children no one can state; that the influence is tremendous no one will deny. Because of the nature of the home project activities, this contact is close and vital

and therefore it has additional force as an educative instrument through the more or less incidental modification of home practices that results. These values extend beyond the home to the whole community. The tangible expressions of pupils become stimuli to others. How many people in the neighborhood treat their potatoes for scab because some boy's project proved so successful!

7. Its by-products are many. Since it gives first-hand experience in a natural setting, many phases of this experience are not immediately useful in the enterprise; however, as already indicated, they supply raw materials for vitalizing all types of instruction. A visit of three days in Chicago gives food for thought connections in manifold ways for years. To capitalize such by-products for general educational ends harmonizes with all fundamental principles of education. The project is rich in illustrations for incidental education; for example, the boy who had a home garden as his project was seen lying prone intensely watching something in the earth. It was a strange insect with many legs. He caught it and took it to the "professor." Incidental to the project, it became a stimulus to intelligent activity, not only in the garden itself, but in the school and elsewhere. It is becoming more and more true, I think authorities agree, that the profits of the farm tend to correlate high with the efficient use of the by-products of the farm. The results of project teaching suggest that the same principle holds true here. The project becomes increasingly valuable to the extent that it gives educational significance to economic production and uses economic production to vitalize the processes of education, a series of give-and-take processes in a real life situation.

IS VENUS CLOUD COVERED?

Mr. Evershed has taken many photographs of the spectrum of Venus in recent years for the purpose (inter alia) of endeavoring to detect the Einstein shift and of testing his own hypothesis that the earth has an effect on the atmospheric circulation of the sun. In the course of this work he found, to his surprise, that a much longer exposure time was needed than was the case in photographing the spectrum of a cumulus cloud on which the sun was shining (Monthly Notices R. A. S., November). Mr. Evershed expected the time to be shorter, for the intensity of sunlight on Venus is 1.92 times as great as on the earth. Allowing for the absorption of Venus's atmosphere, he concludes that if Venus were covered with clouds similar to our cumulus clouds the exposed time would be less on the former than on the latter in the ratio of 1 to 1.3, whereas the contrary is the case. He concludes that the atmosphere of Venus is not cloud laden, but that its lower strata contain much dust in suspension, veiling the surface features. This conclusion is similar to that reached by Prof. Lowell from his observations at Flagstaff.

FREE FALL MACHINE; OR ACCELERATION APPARATUS FOR MEASURING "G": AND THE LAWS OF FALLING BODIES.

By I. Thornton Osmond,

Pennsylvania State College, Carlisle, Pa.

This apparatus is new in principle, construction, and operation; may be easily and cheaply made by any high school; and I have not patented it; it is free.

1. It gives notably good results. See at close of this article.

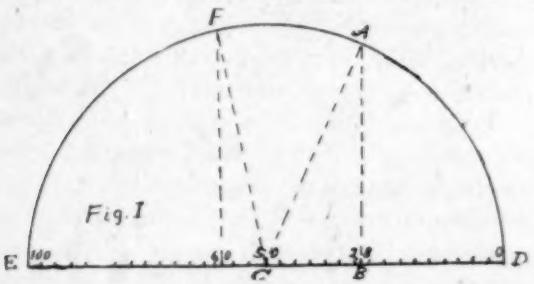
2. The construction is very simple—no delicate parts to get out of order.

3. The student's attention is not diverted and occupied by mechanisms, electro-magnets, motors, bells, etc.

4. *The body falls absolutely free* (except air friction); no counterpoises, nor pulleys, no sliding down rods or grooves with unknown amount of friction.

5. It brings to students, in a practical way, Simple Harmonic Motion, one of the most fundamental, universal, and important forms of physical action.

Principle of Construction and Operation.



If A, Fig. 1, moves with uniform velocity around the semi-circumference, DAE, 180°, the foot B of the perpendicular from A on the diameter will move with a Simple Harmonic Motion along DCE.

Let DCE be graduated into equal parts, say 100; and let t' be the time in which A moves around DAE, 180°, say one second. In what time will B move from D to 28? To 60? Any point?

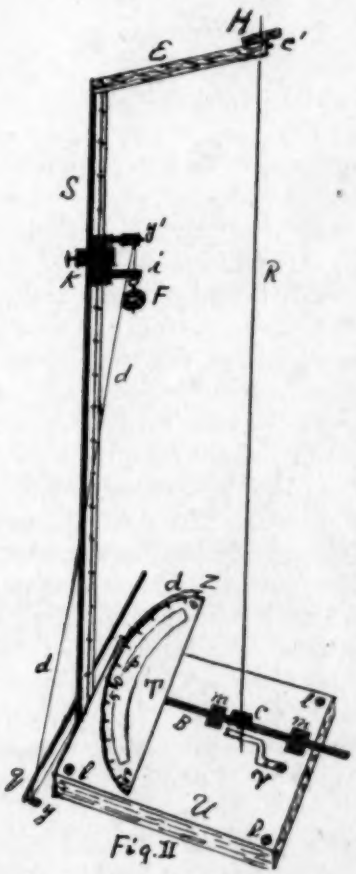
At 28 draw the perpendicular AB, and measure the angle DCA.

Angle DCA : 180° :: 1 second : t, the time required; t = 180° ÷ DCA.

In the same way the time required for B to move from D to 60 is Angle DCF : 180° :: 1 second : t; t = 180° ÷ DCF.

In general, in any Simple Harmonic Motion if the path and period, t′, are known, the time, t, occupied in moving to any point of the path is thus easily found.

Instead of A moving around the semicircumference and B moving along the diameter, let A and B be in a fixed line perpendicular to DE, and the semicircle move past the line BA in such manner that the same number of degrees of the semicircumference will pass this line in equal instants of time. Then DE will move past B with Simple Harmonic Motion, and the time, t, when any point of DE will pass the line AB will be found just as above.



CONSTRUCTION.

S, standard, 2m± high, graduated line on front; E, cross arm; H, torsion head; and c^1, clamp; R, steel rod, 200 cm± long, about 3mm diam.; B, cross bar clamped to R at c; T, segment

attached to B, with arc divided into equal parts, 100±; radius 30±cm; P, piece of thick soft paper, as blotting paper; F, body for falling, sharp point below; K, bracket movable along S; i, pin with vertical slot for thread, from rear, y', small pulley or roller; y, small pulley or roller; d, d, d, thread passing from F through i over y^1 and y and attached to T at Z; q, bar sliding through S, to tighten thread, rotate T and produce torsion of R; v, metal strip with hole through which R passes loosely; m, m, masses movable along B to make the time of oscillation of T what is desired; l, l, l, leveling screws; U, base (may be of any form); material nearly all wood, except R and F, a 3/4 inch iron ball.

OPERATION.

Put K at any desired height on S, and by the leveling screws and plumb line make S vertical. Slightly loosen clamp C^i and by turning H bring the middle line of graduation on T exactly under the plumb, where F will fall from i. Tighten C^i very securely.

Suspend F, 3/4 inch iron ball, by a thread through i over y^i and y and attach the other end to T near the o of graduation. By the thread turn T so that o of graduation comes to the line on the front of S, the point vertically below i, where F will fall. Hold T in this position by the thread and adjustable rod q.

Burn off the thread: about opposite i.

Thus F begins to fall and T to move at the same instant.

Read carefully the distance from the bottom of F (when at i) to the top of T; and also the division on which F struck.

Find, also, the "damping" for the first swing of T, by bringing the o of graduation to the line on the front of S, releasing T and observing how much the highest graduation on T misses of coming to the line on S: a proportional part of this "damping" is to be added to the division on which F falls.

Gravity, "g" and laws of falling bodies from experiments: By the weights m, m, the time, t^i, of oscillation, a single swing of T, was made one second (this makes the calculations simpler than any other value of t^i); and the "damping" was found to be two divisions.

Four experiments gave the following:

	I.	II.	III.	IV.
Distances fallen	168.5 cm	137.3 cm	103.3 cm	71.3 cm
Divisions struck	61.75	53.85	41.80	31.45
(Add for "damping")	1.2	1.0	1.0	0.8
	62.95	54.85	42.80	32.25

To find the times of falling through these different distances we use the principle of Simple Harmonic Motion as explained above.

The work may be done by either of two methods, (a) Instrumental, (b) Trigonometric.

(a) Instrumental:

The drawing, Fig. III, should be quite large and very accurately made and used.

Draw DE, say 20 centimeters length, to represent the 100 equal divisions of the graduation on T: then each cm. is five divisions and two millimetres are one division. Draw the semicircumference DQE.

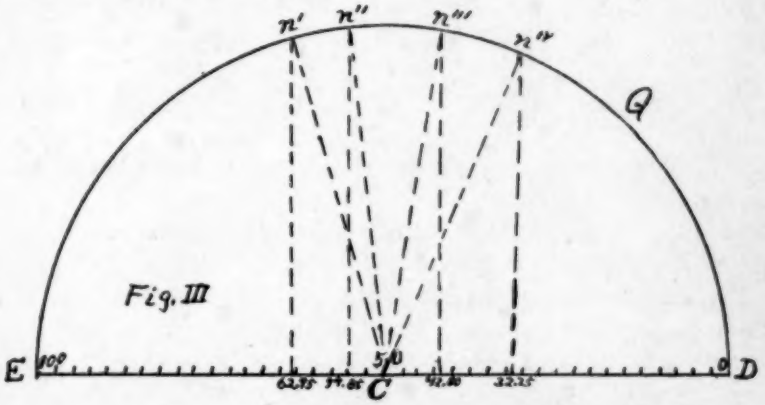


Fig. III

In Exp. I, the ball F struck on division 61.75, or adding 1.2 for "damping," 62.95. Draw the perpendicular from 62.95 to the semicircumference at n^i, and measure the angle DCn^i, 105°.9.

Then, the time of falling, t, is to the time of oscillation, t^i, as angle DCn^i is to 180°.

$t : t^i :: 105°.9 : 180°$, and t^i being 1 second, $t = 0.588$ second.

In the same way the time of falling in each experiment is found; as indicated in Fig. III, n^{ii}, n^{iii}, n^{iv}.

Put the distances fallen, the divisions struck, and the times of falling in a

TABLE.

Exp.	Distance fallen cm	Struck on Division	Corrected for Damping	t seconds	t^2 seconds	First second cm.	"g" cm.
I	168.5	61.75	62.95	0.588	0.3457	487.4	975.6
II	137.3	53.85	54.85	0.528	0.2775	494.7	989.9
III	103.0	41.80	42.80	0.454	0.2065	496.5	998.0
IV	71.3	31.45	32.25	0.383	0.1466	480.6	972.7

Means 489.8 cm, 984.0 cm.

A simple trial shows that the distances fallen are not proportional to the times of falling, but are proportional to the squares of the times.

Thus $168.5 : 137.3 : : 0.588^2 : 0.528^2 = 0.3457 : 0.2775$.

Square the times of falling and put the squares in the fifth column of the table.

LAW I.

In free fall, spaces fallen are proportional to the squares of the times of falling

$$S : S' : : t^2 : t'^2 \quad \text{.....(1)}$$

By Law I, find the space fallen in the first second:

168.5 cm : x cm : : 0.3457 sec. : 1^2 sec.; x = 487.4 cm from Exp. I.

137.3 cm : x cm : : 0.2775 sec. : 1^2 sec; x = 494.7 cm from Exp. II.

103.0 cm : x cm : : 0.2065 sec. : 1^2 sec.; x = 496.5 cm from Exp. III.

71.3 cm : x cm : : 0.1466 sec. : 1^2 sec.; x = 480.6 cm from Exp. IV.

The mean of the values of x from the four experiments is 489.8 cm [should be 490 and 1 or 2 tenths].

LAW II.

In free fall, a body falls 490 cm in the first second starting from rest.

By Law I, derived from our experiments, the distance fallen in two seconds is 2^2, or 4, times the space fallen in one second, which from our experiments is 489.8 cm (take it 490); 4x490 = 1960 cm.

In 3 seconds the space fallen is 3^2, or 9 times as far as in the first second; 9x490 = 4410 cm. In 4 seconds, 4^2, or 16, times the space fallen the first second; 16x490 = 7840 cm. And so on.

$$S = 490\, t^2 \quad \text{.....(2)}$$

In each successive second the body falls 980 cm farther than it fell during the preceding second, so we have

1. A freely falling body has Uniformly Accelerated Motion

2. Gravity, "g," is a force that acting for one second on a free body produces an acceleration of 980 cm per second

"g" = 980 cm per second per second.....(3)

Since by a uniform acceleration the velocity of a freely falling body is increased at the rate of 980 cm per second, we have

Law III.

In free fall, the velocity at any instant is 980 times the number of seconds.

$$V = 980t = gt \quad \text{.....(4)}$$

The experiments give $S = 490t^2$, and $g = 980$, or twice 490; so we may rewrite Eq. (2) as

$$S = 1/2\ gt^2$$

The three laws and the equations that we have found by our experiments are sufficient for the solution of all problems of freely falling bodies. Obviously they are also the laws and formulas of all Uniformly Accelerated Motion.

(6) Trigonometric Method:

Instead of making a drawing, like Fig. III, the time of falling may be found by use of a table of cosines. It should be a table giving the cosines for every minute of each degree, but briefer tables can be used fairly well by taking proportional parts.

Referring to Fig. III, it will be seen that the distance between the division struck by the falling body and the centre of the path, 50, is the cosine of the angle whose ratio to 180° is the same as the ratio of the time of falling to the time of oscillation of T. So, from a cosine table it is easy to find the time angle without drawing a figure.

Example. In experiment IV the body fell 71.3 cm and struck on division 31.45; adding 0.8 for "damping" makes it 32.25. Distance to centre, $50-32.25 = 17.75$. The ratio of this to the radius, $18.75 \div 50 = 0.3550$, the cosine of 69° 12′, or 69°.2.

69°2. : 180° : : t : 1 second; t = 0.384 sec., time of falling.

If the division struck is beyond the centre, 50, as in Experiment I, the angle found from cosine tables that go to only 90° will be the supplement of the time angle. Division struck 61.75, add 1.2 for damping, 62.95. $62.95-50 = 12.95$. $12.95 \div 50 = 0.2590$, the cosine of 75°. The time angle sought (DCn^i, Fig. III) is the supplement of this, 105°.

Values of "g", from 8 experiments, consecutive experiments, not selected by rejecting poor ones:

Exp.:	I	II	III	IV	V	VI	VII
"g" :	973.36,	992.86,	980.00,	985.90,	967.10,	963.90,	988.20,

VIII Mean
980.96 : 979.03

This work was done with the first machine, which I made by hand with a few common tools.

COMMON EVIDENCES OF AIR PRESSURE.

By Stephen S. Visher,

Indiana University, Bloomington, Ind.

The atmosphere exerts a pressure of nearly fifteen pounds per square inch, or a ton to the square foot at sea level. It would seem likely that there should be many results of this considerable pressure. However so perfectly is life and nature adjusted to this pressure that there are very few evidences of the pressure alone. The downward pressure of the atmosphere is balanced by a like pressure in the opposite direction by air beneath or within most objects. Air pressure becomes evident to our senses only where there are local differences in the amount of air pressure. Where such differences occur, air rushes, or tries to rush, into the place of lesser pressure, and this movement or force is conspicuous.

In most texts dealing with the air, several evidences of air pressure are enumerated. Upon consideration, it will be recognized that practically all are not evidences of air pressure itself, but are results of differences of air pressure. Perhaps the only common evidence of air pressure not involving local differences in air pressure is the influence of air pressure upon the rate of evaporation and upon the boiling point. Though this influence is exceedingly common, in that it affects all common cooking greatly, it is not simple nor conspicuous, nor determinable without special equipment. It is due to the fact that the escape of molecules from the liquid is interfered with by collisions with the overlying molecules. The greater the air pressure, and hence the denser the air, the larger the prospects of collision and consequent return by rebound of the molecule which was leaving the liquid. Where the air pressure is slight, as at high altitudes, water boils at low temperatures. (With each rise of 550 feet, the boiling point is lowered about one degree F.) When a marked cyclonic low passes a point, the boiling is more than 3° F. lower than when a high (anticyclone) is over that point.

It may be worth while to list a considerable number of common results of local differences in air pressure (commonly called evidences of air pressure).

(1) Wind is air rushing from a place of greater air pressure towards one of lesser air pressure. Because of the influence of the rotation of the earth and of centrifugal force, the movement is not often direct. If it were direct, the differences of pressure would soon be equalized and the wind would soon die down.

(2) When two objects with flat surfaces, pieces of smooth plate glass, for example, are put together, they are hard to separate. The difficulty of separation is related to the partial vacuum which is created between the surfaces as they are first being forced apart.

(3) Cardboard milk-bottle covers are held down by the greater air pressure above them than below. The air originally below the cap is partly dissolved in the fresh, unaerated milk and a partial vacuum is created below the cap.

(4) After fruit, vegetables, or other substances which have been sealed into a can while hot have cooled, the can is often dented by the greater pressure of the outside air than of the inside air.

(5) A cork placed in the neck of a hot bottle is forced by the greater outside air pressure far into the neck as the contents of the bottle cool and contract.

(6) When hot tumblers, or other dishes, are inverted upon a smooth wet surface, and allowed to cool, they are often somewhat difficult to remove. If they are standing in a shallow layer of water when they cool, the water may be forced by the greater air pressure outside to enter the dish.

(7) The liquid in a liquid barometer is kept up by the pressure of the air upon the liquid in the cup into which the open end of the tube is immersed. At the closed end there is a vacuum. An aneroid barometer is essentially an air-tight box with one flexible side. When the pressure of the outside air is greater than that inside the box (or greater than that of a spring inside of the box if the box is not filled with air), the flexible side is depressed slightly. When the inward pressure of the atmosphere is less than the pressure outward of the contents of the box, the flexible side bulges out.

(8) Liquid rises in soda fountain straws and in similar straws when the air pressure on the liquid into which the tube is immersed is greater than that on the liquid near the end of the tube.

(9) The common self-filling fountain pen is filled as a result of the greater air pressure upon the ink in the bottle than upon the ink inside of the pen.

(10) Flow of a liquid along a siphon is started by creating a partial vacuum at the longer end of the bent tube. The liquid continues to flow, as long as liquid is available, because it cannot stop flowing without creating a vacuum where the liquid column breaks. The height to which the liquid can be raised in a siphon depends upon the amount of air pressure.

(11) Many automobiles have a vacuum gasoline feed. There is a hole in the cover of the gasoline tank through which the air enters and exerts its pressure. If this tiny hole is stopped up, the gasoline will not flow.

(12) All liquid containers which are emptied through a small hole must have another hole through which the air can enter. In other words, both bungholes of a barrel must be open; otherwise, the efforts of the outside air to enter the vacuum created by the escape of the liquid will soon prevent the flow of the liquid.

(13) The pus-cup, in common use in hospitals, is placed over boils after having been warmed over a flame. As the cup cools, the flesh is gradually forced by the outside air pressure to enter the cup a short distance and the pus is gently squeezed out into the cup. The cup is removed by pushing one finger under the edge of the cup and thus allowing the air to enter.

(14) The common valve pump operates because of air pressure. A stroke of the piston partially exhausts the air above the air-tight valve. Air pressure on the water in the well or cistern forces some of the water up past the valve. Priming is a means of making a leaking valve air-tight.

(15) The ascent of warm air, as in a chimney, is due to the difference in the pressure exerted by cold and by warm air. If not tightly confined, warm air exerts less pressure than cold air because warm molecules vibrate more and hence pack less closely than do cooler molecules. Thus there are fewer molecules per unit volume of warm air than of cold air, where other conditions are similar.

(16) The rapidity of ascent of a hydrogen-filled balloon varies with the air pressure, the cause of its ascent. The height to which it may ascend is likewise limited by air pressure. It cannot ascend to where the amount of pressure is nil. Therefore, it will always be impossible to send balloons to Mars, for example, as impossible as it will be for an aeroplane to ascend to where the air pressure is below a definite minimum.

(17) Part of the destructiveness of tornadoes is due to the slight air pressure in their vortexes. Many closed buildings are disrupted by the relatively greater outward pressure of the air within them.

(18) Thunder is largely due to the rush of hot air out from the path warmed by the lightning discharge, and later, after cooling has occurred, the rush back to fill the partial vacuum so created.

(19) The report following an explosion, such as when a gun is fired, is due chiefly to the rush of air and gases from the center of great pressure (the explosion).

(20) Tones from the pipe organ, and from other wind instruments are likewise made by the rush of air from a place of greater pressure to one of lesser pressure.

(21) All sound waves make themselves evident to us because they are variations in the amount of air pressure. The diaphragm of the ear is adjusted to a definite amount of air pressure. When more air presses upon it, it is indented, and the impulse is sent along the nerve.

(22) A fast moving train creates a partial vacuum under and behind it. Sometimes heavy mail bags thrown from the mail car near the front end of the train are carried beneath the train by air rushing into this partial vacuum.

(23) Racing automobiles have long "tails," so shaped that instead of a partial vacuum just behind the car, there are air currents which help push it ahead.

(24) It has been proven by investigations in aero-dynamics that an airplane is lifted not alone by normal impact due to the forward movement of the sloping plane against air, but also as a result of the partial vacuum created just above the sloping plane. For mono-planes, nearly ¾ of the total lifting is due to this effect. For biplanes this effect is slightly less important.

(25) Vacuum cleaners clean by means of the air which rushes into the partial vacuum developed by the pump. The greater the atmospheric pressure, the greater the suction power of the cleaner.

(26) The player piano, and many other similar mechanical devices are operated with the help of the atmospheric pressure. Air forces its way through the perforations in the paper to enter a partial vacuum created artificially within the instrument. As it enters, the hammer is released.

(27) Compressed air is used very extensively in modern industry. Its use depends upon the fact that the normal air pressure is relatively slight. The less the outside air pressure, the more efficient is the compressed air.

PEAT IN 1919.

According to a preliminary statement by the United States Geological Survey, Department of the Interior, 76,301 short tons of peat, valued at $860,841, were sold in 1919. This is a decrease of 30,960 tons and of $186,402 compared with the sales in 1918.

A PROBLEM AND ITS NUMERICAL SOLUTION.

By W. W. Sleater,

University of Michigan, Ann Arbor, Mich.

Not long ago when a somewhat unexpected assertion was made in a college physics class, a student inquired whether that result was practical or "only theoretical." That some ideas are practical, useful, and important, while others, though true enough, are theoretical, and therefore of no consequence, has always been a common conviction. No doubt such a distinction exists, but the conviction is objectionable when it is felt, if not precisely maintained, that a result is useless because it is theoretical. The same sort of comparison exists in the public mind between academic results and practical ones, a comparison having its perfect expression in the remark of Mr. Shaw that those who can, do, while those who can't, teach. No one who recognizes that teaching itself is doing will feel the sting of Mr. Shaw's irony. For others it is perhaps intended and by them no doubt deserved. It has, however, been generally supposed that an "academic" result savors of seclusion and perhaps of luxurious other-worldliness. Though the work of scientists in the war may have modified or partially removed that notion, it still lives, and it is not altogether groundless.

Such truth as there may be in the belief that academic conclusions are of negligible importance arises from the fact that the problems assigned and solved in school and college are always selected. They are carefully chosen, made up on purpose even, like chess problems, rather than taken at random from everyday experience. The rigor of the selection is very real to the teacher who supplements his textbook by outside examples. One hesitates to give to his class a problem he himself has not solved—he hesitates, at least, after having the not uncommon experience of being unable to answer his own question.

There is, of course, a legitimate reason for this selection. One does not assign to beginners in algebra a problem involving quadratics. But there is also a motive in the exclusion of problems which is at best doubtful. Students have been known to despair of the correctness of a solution because the answer does not "come out even." To conserve their time, and to keep his pupils in a comfortable and hopeful frame of mind a teacher may exercise more than paternal vigilance over the tasks assigned. The process of selection may exclude the common and so to speak unexpurgated questions which arise

in the world outside of school, and in which, of course, the likelihood of getting integral numbers as results is extremely small. This kind of exclusiveness is responsible for part of the unwelcome significance of "theoretical" and "academic."

A boy must not be discouraged, of course. But complete shielding either in home or school may have unfortunate results. It may, and no doubt often does, permit an unwarranted confidence which the young man has neither promise nor performance to justify. Or it may, in a boy conscious of his own limitations, produce a damaging timidity and self-distrust.

If the repertoire of methods by which we attack our problems could be extended, and their somewhat rigid limitations be removed we might perhaps be more hospitable in receiving questions. If we were spared the necessity of refusing to try problems and would agree so to speak, to meet all comers, the reproach of being academic in so far as it is a reproach might in a measure disappear. It is in the hope of encouraging this kind of hospitality that the following problem is presented. Neither the problem nor the nature of the solution is new, but they may serve to recall unused resources, and to encourage their application in other fields.

It is of course well known, but it is perhaps too seldom taught, that a numerical solution of any sort of equation can be made by trial. Moreover, except in rare cases, or specially selected ones, the root of an equation is obtained only approximately, being carried out only as far as necessity requires, even when the general solution is obtained. Now, although a literal solution of an equation cannot be found or is too hard to find, the numerical value of the unknown may be obtained by trial, and with as great precision as occasion demands. To illustrate, suppose

$$x^2+3x-8=0.$$

Solved in the ordinary way, the value of x is $-3/2 \pm 1/2\sqrt{41}$, or, *to five decimal places*, $x = 1.70158$ or -4.70158. A boy completely ignorant of quadratics might obtain this result and with no great amount of labor. It will not be necessary to go through with this problem the steps in the solution by trial. The third number tried after 1 and 2 gave $x^2+3x = 8.00005$. It may be remarked, however, that, although in this case the solution by trial to five decimal places is more work than the ordinary method, the difference might be relatively less if five more significant figures were required.

Now, the object of this paper may still be obscure, and its

readers are perhaps objecting to the project of solving quadratic equations by arithmetic, and they may be wishing to remind the author that it is trouble enough to teach boys what textbooks and principals require. No one knows this better than the author himself and his purpose may be specifically stated again. In the face of many problems which quite naturally arise we are in the position of a beginner in algebra confronted with the necessity of obtaining the value of x from $x^2+3x-8 = 0$. We may not know how to write out a general solution. But we can obtain a numerical root with as great precision as the nature of the case requires.

The particular problem which I wish to state and at least in outline to solve is as follows:

A bar magnet, pole strength 100 c. g. s. units and 20 cms long is placed at right angles to a uniform magnetic field in which H = 0.19 gauss. Locate the neutral points, that is, find the points at which the resultant field is zero. The magnet and field are disposed as in Fig. 1.

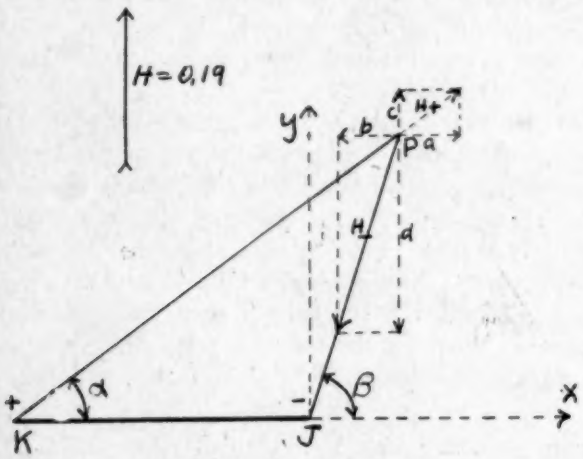


Fig 1.

Evidently the neutral points lie in the plane determined by H and the magnet. Also, at the neutral point, the two components of field, due to the two poles respectively, which are parallel to the bar are equal and opposite. The two components perpendicular to the bar must differ by 0.19. In Fig. 1, KJ is the magnet, H_+ and H_- the two fields at P = (x,y), a, b, c, and d the field components parallel to the x and y-axes, and H is the original field equal to 0.19 gauss. Then by the conditions of the problem

$$\text{A}\begin{cases} a = b \\ d - c = 0.19. \end{cases}$$

From these equations we must find x and y, and it is first necessary to express a, b, c, and d, in these terms. Evidently $H_- = 100/(x^2+y^2)$, $H_+ = 100/[(x+20)^2+y^2]$, so that

$$a = H_+ \cos\alpha = \frac{100}{(x+20)^2+y^2} \cdot \times \frac{x+20}{\sqrt{(x+20)^2+y^2}}$$

$$= \frac{100(x+20)}{[(x+20)^2+y^2]^{\frac{3}{2}}}$$

$$b = H_- \cos\beta = 100/(x^2+y^2)^{\frac{3}{2}} \cdot x/(\sqrt{x^2+y^2}) = 100x/(x^2+y^2)^{\frac{3}{2}}$$

$$c = H_+ \sin\alpha = \frac{100y}{[(x+20)^2+y^2]^{\frac{3}{2}}}$$

$d = H_- \sin\beta = 100y/(x^2+y^2)^{\frac{3}{2}}$. Therefore equations (A) become

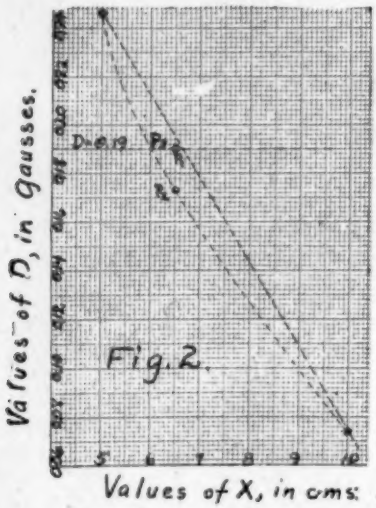
$$\text{(b)} \quad \frac{100y}{(x^2+y^2)^{\frac{3}{2}}} - \frac{100y}{[(x+20)^2+y^2]^{\frac{3}{2}}} = 0.19$$

$$\text{(c)} \quad \frac{x}{(x^2 \times y^2)^{\frac{3}{2}}} = \frac{x+20}{[(x+20)^2+y^2]^{\frac{3}{2}}},$$

which give as roots the values of x and y locating the points we wish to find.

These equations may be so manipulated that x is expressed in terms of y by a cubic equation. Without attempting such a solution, the results may be obtained as follows: Assign arbitrarily a value to x, find the value of y from (c) and substitute these numbers in (b). The numerical value of the difference representing the first member of (b) will be called D, and D should equal 0.19. The problem has now become a matter of economy. The single equations arising in the process are pure quadratics, a circumstance accidentally favorable, and the actual labor, if logarithms are used, is not great. It must, however, be reduced to a minimum. Here a graphical method is applicable, and it is to suggest that method that the problem is undertaken. Values of x, first those arbitrarily chosen, are plotted as abscissas, and values of D as ordinates. Then as soon as two points are located a first approximation to the root, something more than a guess,

becomes possible. It will be the abscissa of the point in which the horizontal line through $D = 0.19$ intersects the straight line through the two points first located. Fig. 2 shows this point as near P_1. The straight line is located by using $x = 10$ and $x = 5$, from which $D = 0.074$, and $D = 0.246$ respectively. Now, using $x = 6.5$, the abscissa of P_1, $D = 0.1735$.



The new point is P_2, and it is now possible to correct the straight line first employed. A smooth curve through the original points and P_2 suggests $x = 6$, and this gives $D = 0.18975$. It may now be observed that as the range along our axes involved in the approximations becomes smaller the curve may with smaller error be considered a straight line, and desirable changes in x may be computed by direct proportion. In Fig. 2, P_3 shows the point whose abscissa is 6, and by applying the proportion as suggested, using P_3 and P_2, it is found desirable to try $x = 5.9907$. This gives $D = 0.19020$. In Fig. 3, P_1 and P_2 are points whose abscissas are 6 and 5.9907 and the straight line, or a direct proportion, gives

$$x = 5.9948, y = 18.6996.$$

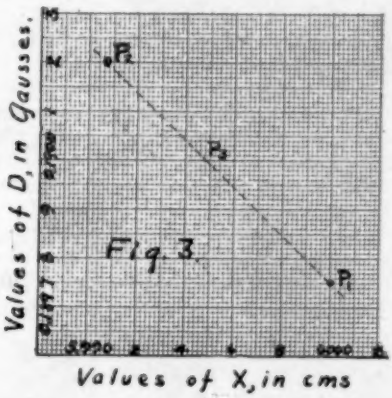
These values are no doubt correct as far as they go. They could moreover have been carried somewhat further if the approximations immediately preceding had contained more significant figures. It is plain that another proportion would carry the result beyond the reach of any ordinary logarithm tables. The problem is now solved.

It is interesting to note that equations (b) and (c) could be

obtained perhaps more easily in another way. By first writing an expression for the potential at P, we should have

$$V_p = \frac{100}{\sqrt{(x+20)^2+y^2}} - \frac{100}{\sqrt{x^2+y^2}}$$

If now we form $-\frac{\gamma v}{\gamma x}$ and $-\frac{\gamma v}{\gamma y}$, the partial derivations of V with respect to x and to y at the point in question, we obtain the values, as in (b) and (c), of the several components of the field. This is an example of the physical meaning of a partial derivative and of the usefulness of partial differentiation.



It may be remarked now, if any readers have followed thus far, that the necessity of knowing the position of the neutral points near a bar magnet is not extremely pressing, that the problem chosen to exemplify a practical method is in fact somewhat academic. It will be admitted, however, that the particular example chosen is not essential to the purpose of the paper. Not long ago, in the course of some work done for the manufacturers of certain very useful kinds of glass, it became necessary to find the absorption and reflection coefficients of particular glasses for various wave-lengths in the infra-red spectrum. It was found that by comparing the intensities of the radiation at the particular wave length in the spectrum of a Nernst glower, first when a thick piece of glass screened the glower, second when a thin piece replaced the thick one, and third where neither was interposed in the beam, it was possible to separate the effects of reflection and absorption, to find the absolute losses of energy due to each, and to calculate the coefficients required. This required the solution at each wave length involved of an exponential equation. It was satisfactorily accomplished by the method above set forth.

Finally, it must not be urged against the pertinence of the suggestions of this paper that the methods of trial lack the elegance and generality characteristic of genuine mathematical thought. This presentation is made in behalf of practical results, so-called, and elegance and generality are sometimes or to some people matters of academic importance only. At any rate a boy may afford to extend his command over the difficulties likely to confront him and his teachers may not be unwilling to strengthen the foundations of his competent resourcefulness and conscious power.

NATIONAL RESEARCH COUNCIL.

The National Research Council, a cooperative organization of leading scientific and technical men of the country for the promotion of scientific research and the application and dissemination of scientific knowledge for the benefit of the national welfare, has elected the following officers for the year beginning July 1, 1920: Chairman, H. A. Bumstead, professor of physics and director of the Sloane physical laboratory, Yale University; First Vice-Chairman, C. D. Walcott, president of the National Academy of Sciences and Secretary of the Smithsonian Institution; Second Vice-Chairman, Gano Dunn, president of the J. G. White Engineering Corporation, New York; Third Vice-Chairman, R. A. Millikan, professor of physics, University of Chicago; permanent secretary, Vernon Kellogg, professor of biology, Stanford University; Treasurer, F. L. Ransome, treasurer of the National Academy of Sciences.

The Council was organized in 1916 under the auspices of the National Academy of Sciences to mobilize the scientific resources of America for work on war problems, and reorganized in 1918 by an executive ord r of the President on a permanent peace-time basis. Although cooperating with various government scientific bureaus it is not controlled or supported by the government. It has recently received an endowment of $5,000,000 from the Carnegie Corporation, part of which is to be expended for the erection of a suitable building in Washington for the joint use of the Council and the National Academy of Sciences. Other gifts have been made to it for the carrying out of specific scientific researches under its direction.

"EXPLOSIVE DUSTS" FILM ISSUED.

Why dust is dangerous is shown conclusively in a one-reel motion picture, "Explosive Dusts," recently issued by the United States Department of Agriculture, in cooperation with the United States Grain Corporation.

The old two-reel picture is being retained for the use of workers in the Bureau of Chemistry. The new one-reeler is especially designed for showing in high schools and other scholastic institutions, as well as before grain and milling men, fire prevention and insurance associations, and others directly interested in the subject.

Requests for the loan of the film should be made through some field worker of the Department of Agriculture, or they may be sent directly to the department. Arrangements also have been made enabling outside persons and institutions to buy prints of the film at the cost of manufacture.

THE USE OF CHARTS FOR PROSE PROBLEMS.

By Jos. A. Nyberg,
Hyde Park High School, Chicago.

In a previous paper[1] a method of solving time, rate, and distance problems by using charts on diagrams was discussed. The present paper considers how charts may be applied to the solution of some other prose problems. Although the method can not be used for all problems it is useful for beginners, particularly those who do not know where and how to attack a problem.

The "age" problem is so simple that it is used during the first months of algebra. Typical of it is: A father is five times as old as his son; two years hence he will be four times as old. Find the age of each now. The chart is but a concise tabulation of the given information:

	1920	1922
father	$5x$	$5x+2$
son	x	$x+2$

The explanation given to the class for such a problem would be: Two people are always spoken of, and we enter their names to the left of the chart; also, two distinct dates are always mentioned and we enter their corresponding years at the top of the two columns. To make everything as concrete as possible, I use 1920 instead of the words *now* or *at present*. Instead of 1922, we could write $1920+2$. The most important idea to impress on their minds is that the entries in the second column (under 1922) should be made without consulting the book. The book is unnecessary because if we know a person's age now, we can without algebra predict his age at any future year. The entries are made by adding or subtracting from the first column a certain number—in fact the same number that obtained 1922 from 1920. In my less serious moments I tell the class that, having made the entries under 1920, my text should close automatically and, like some safes, can not be opened until I have filled the second column from my head. The equation is next obtained by relating the last two entries in the chart. There is nearly always some pupil in the class who will want to enter $4(x+2)$ in the chart in place of $5x+2$. While he could of course derive the same equation in spite of such an entry, his method of derivation would be more difficult for the majority of the class to

[1] School Science and Mathematics, June 1920.

understand because his method can not be reduced to the rules given later.

The remaining illustrations will involve charts having three columns, and the "age" problem is a splendid introduction to them. Representative of the "coin" problem is: A man has two more nickels than dimes, and twice as many quarters as nickels. If he has \$4.35 how many of each kind of coins has he? The complete chart appear thuss:

	How many	Value of 1	Total value
Nickels	$x+2$	5	$5(x+2)$
Dimes	x	10	$10x$
Quarters	$2(x+2)$	25	$50(x+2)$

Again we note that the equation is derived from the last entries.

A variation of the above is the flower problem: A florist sold some roses at 25c each, three times as many tulips at 15c each, and twice as many carnations as tulips at 10c each. If he received \$45.50 how many of each did he sell? The chart would be similar to the preceding, and the columns would have the same headings. When working this problem I always point out to the class the similarity between the chart and the order pad of a grocery clerk which may, for example, read:

2 doz	eggs	80	1	60
3 doz	oranges	75	2	25

The similarity is evident. The algebra has merely interchanged the first two columns, stating the items first and then the quantity. And this change, we might note, is in favor of algebra, for actually the shopper decides first on what to buy and next on the amount.

The reader will have noticed that in using these charts, the pupil can follow certain general rules[2] (the second may appear ungrammatical in statement, but it places the emphasis where it belongs):

1. Write down what the problem talks about; for example, a father and son, nickel, dimes, etc., tulips and carnations, etc.

2. Whatever the problem asks for, fill that column first—with x and the various quantities of x.

3. The last[3] of the three columns must be filled from your head, not from any information in the problem.

4. The entries in the column filled by rule three, and any unused information are then used to make the equation.

Various types of problems will of course require various headings for the columns; and when such a new problem arises, the class should work out for itself the headings. One column will always be devoted to whatever is asked for in the problem; another column will involve the given information; and the third will involve whatever can be computed from the other two. Thus in the coin problem, I lead up to the chart by asking suggestive questions, as: What does the problem talk about? What does it ask us to find? How do the coins compare in value? Of what importance are their relative values? A cashier puts his nickels, dimes, quarters in separate compartments in his cash register; after counting how many he has of each, how does he find his total receipts?

After a pupil has grasped the rules, variations may be introduced so that x and its functions appear in the second column instead of the first. Frequently a mere rewording of the problem asking for a different unknown will bring this about; thus: A merchant has 200 lbs. of Formosa tea, and 300 lbs. of Ceylon tea which is worth per pound 5c more than twice the other. At what prices shall he sell them to receive $485? And when the pupil is ready to handle fractions, he can solve: A company has a 2 ton truck and a 1½ ton truck. At the end of the month the first truck has handled 100 more tons than 5 times the second. If the number of trips made by both was 335, how many tons were shipped by each truck? The headings of the columns would be: Number of trips, Capacity, Total haul. Also we can use problems dealing with the number of revolutions made by a wheel in going a certain distance. In fact, whenever quantities satisfy a relation $xy = z$, the chart is useful.

The method also has advantages in dealing with problems leading to simultaneous equations; the general procedure is the same, although the rules can not be followed rigidly, for x and y may not appear in the same column, nor can both equations be derived from the last entries. Thus: Find the number of seats and price of admission to a theatre, knowing that if there were 400 fewer seats, the price would have to be 10c more, and if there were 500 more seats, the price could be 10c less to get the same receipts. The three columns would be headed:

[3] Note the similarity between these rules and those stated for distance, rate, and time problems.

[4] Not necessarily the third column.

Number of seats, Fee, and Total receipts; and the three horizontal rows would be labeled as "Actual condition" (with x seats and y the price), first and second hypothetical case. Other similar problems are those involving people who share expenses on a trip, trains running under hypothetical conditions, rectangles changed by altering their dimensions, etc.

Problems leading to simultaneous equations also afford an opportunity of showing that the chart is really only a means of tabulating our information. Consider the problem: Eight years ago, A was twice as old as B, nine years hence he will be three halves as old as B, Find their ages. Here the three columns are headed 1912, 1920 and 1929 and the entries made are: Under 1920, x and y for their ages; under 1912, $x-8$ and $y-8$; under 1929, $x+9$ and $y+9$. To the class I explain that since we are dealing with two unknowns we must now have two equations, or two relations between the six entries in the chart. Any two relations will furnish a problem; for example, saying A's age in 1912 is a third of B's in 1929, or B's age now is half the sum of A's age in 1929 and B's in 1912. Such relations relate entries in various columns and rows. If the pupils are invited and encouraged to make and try out a few relations of their own, their conception of an equation and its uses can thus be broadened.

The coin problems mentioned above have variations involving more than a blind use of the chart. Thus: A cashier has \$5.20 in dimes and quarters. After taking out 9 dimes and 1 quarter, he has five times as many quarters as dimes. How many of each did he originally have? Here one equation involves the values of the coins and the second the number of coins. The so-called "work" problems contain an additional variation, for if x and y stand for the number of days required by A and B to do a piece of work, then x and y do not appear in the chart, for it is more advisable to enter $1/x$ and $1/y$ in a column headed "part of work done in 1 day," the other two columns being "days worked" and "total part of work completed."

Problems dealing with mixtures of alloys, or with mixtures of chemical solutions of various strengths are always puzzling to the pupil, chiefly because he can not express the ideas which he knows should enter into the problem. But when he tabulates these items, much of the trouble vanishes even though he does not use in his equation all the data. Thus: A chemist wishes to mix an alloy of 60% copper and 40% nickel with an alloy of 30% copper and 70% nickel to obtain 12 tons of an alloy of

42% copper and 58% nickel. How many tons of each shall he use? The chart is:

	Q'n'ty	Copper	Nickel
First alloy	x	$.60x$	$.40x$
Second alloy	y	$.30y$	$.70y$
Final alloy	12	$.42(12)$	$.58(12)$

The reader will notice that the four rules given above have not been followed strictly. The third column is filled from the information in the problem, and the equation is not derived from the last entries alone. (The problem could be solved by following the rules—we have merely tabulated too much information). This does not prove that the charts are useless. They are intended as aids to help backward pupils and to develop orderly methods of procedure. They can be used for still another purpose. Every teacher is confronted with pupils who are not dull but are lazy and plead inability to work a problem when they have not tried it. Before extending too much help to such a pupil, it is useful to insist that he tabulate his information in a chart before he can receive help. The teacher can then see at a glance what the trouble is, and make sure that the pupil has at least made an honest effort.

The best variation to test the pupil's ability to absorb ideas rather than ability to handle a formal method, would be one in which the rules appear to fail so that the pupil must resort to his own ingenuity. Such a problem might be one which does not ask directly for any element specified under the headings of the columns, but which could be determined from them. An illustration of this was given in the paper on time rate and distance problems. Another illustration, which, however, is more of a curiosity and a test of ability to understand the English language, is the classic: Mary is twice as old as Ann was when Mary was as old as Ann is now. The two columns of the chart are headed "is" and "was." The words "Mary is twice as old as Ann was" tell us to enter $2x$ for Mary under "is," and x for Ann under "was." Let us say that d is the difference in years between the two columns. Then we enter $2x-d$ under "was" for Mary, and $x+d$ for Ann in the "is" column. The words "when Mary was as old as Ann is now" tell us that $2x-\text{d} = x+d$. Hence, any numbers that satisfy the relation $x = 2d$ will answer the problem, and their ages might be 4 and 3, 8 and 6, etc.

THE TEACHING OF LOGARITHMS AND THE SLIDE RULE IN THE NINTH GRADE.[1]

By C. Eben Stromquist,

University of Wyoming.

The question of introducing logarithms and the slide rule in the mathematics course of the ninth grade is only one of the many problems connected with the reorganization of the high school curriculum in general and of the mathematics course in particular.

Suggestions for teaching logarithms early in the high school have been made before, for instance, by Professor Meyer in School Science and Mathematics for 1905 and by Professor Moritz in the same journal for 1909. According to the report of Professor J. C. Brown, *Curricula in Mathematics*, United States Bureau of Education Bulletin 1914, No. 45, the topic is not taught in the ninth grade in this country, but we find, on the other hand, in his summary of the ninth year work the statement that "the subject of logarithms is introduced in most of the countries, and in some schools in Germany the pupils become familiar with the slide rule." This refers to some sixteen countries studied in his report. We find also that, with practically no exception, the texts on the first year algebra in this country do not contain the topic of logarithms.

It is hardly necessary to urge the importance of logarithms and the slide rule as topics in the high school course of mathematics. Their practical value in all fields that require computations must be admitted by all who are familiar with these powerful and convenient tools. The arguments for introducing the topics as early as in the ninth grade are the following: The student can thereby economize much time in his school work in mathematics and science and he will see a useful application of mathematics. Furthermore, there seems to be a growing tendency, in this country, to reduce the mathematics requirement for graduation from high school to one year and this year would therefore be the only opportunity afforded to teach the topics to many of the high school students.

The real question regarding introducing logarithms and the slide rule in the ninth grade is, therefore: "Can these topics be presented in a manner suited to the age of these students and without sacrificing more important or more suitable material?"

[1]Read before the Rocky Mountain Section of the Mathematical Association of America at Colorado College, April 3, 1920.

The purpose of this paper is to outline a method of presenting these topics in the ninth grade.

Topics Needed For Preparation.

The method is based upon a careful choice of examples and problems from the following topics which are needed as a preparation for teaching logarithms or the slide rule.

Tabulation and graphs: This should include tabulating and graphing linear equation and such equations as $y=x^2$, $y=x^3$, $y=x^{\frac{1}{2}}$, $y=x^{\frac{1}{3}}$. Considerable drill should also be given the student in reading from graphs values of y corresponding to given values of x, and vice versa.

Exponents: The student should be taught the meaning, without formal definitions and proofs, of positive and negative, integrals, fractional and zero exponents. He should be given drill in applying, to simple examples only, the four laws of exponents, namely, multiplication, $a^m \times a^n = a^{m+n}$; division, $a^m \div a^n = a^{m-n}$; involution, $(a^m)^n = a^{mn}$; evolution, $(a^m)^{1/n} = a^{m/n}$. The emphasis should be upon simple numerical examples and problems.

Extraction of square root of arithmetic numbers: As special problems under this topic the student should compute, and keep the results for future use: $\sqrt{10}$ (i. e. $10^{\frac{1}{2}}$) to four or six decimal places; then $\sqrt[4]{10}=10^{\frac{1}{4}}$, $\sqrt[8]{10}=10^{\frac{1}{8}}$, and then $10^{y/8}$, for $y=-6, -5 \ . \ . \ ., -1, 0, +1, +2 \ . \ . \ ., +8$. If time permits, it is well to compute $10^{y/16}$ to get more accurate results in the work which is to follow.

The preceding preparatory topics are almost invariably included in the first year high school algebra course. The only change suggested is in the nature of the problem material and in selecting for special use certain problems to illustrate square root and the simpler definitions and rules of exponents.

Tabulation and Graph of $x=10^y$.

The student is now ready to tabulate $x=10^y$ for $y = -\frac{6}{8}, -\frac{5}{8}. \ . \ . \ 0, +\frac{1}{8} + \ . \ . \ . \ +1$. This is simply a matter of collecting and arranging the results already worked out. This will give the following table in which the values of y have been expressed as decimals:

x	0.178	0.237	0.316	0.422	0.562	0.750	1.000	1.334
y $-\frac{6}{8}$	−0.750	−0.625	−0.500	−0.375	−0.250	−0.125	0.	+0.125
x (continued)	1.778	2.371	3.162	4.217	5.623	7.499	10.000	
y (continued)	0.250	0.375	0.500	0.625	0.750	0.875	1.000	

Careful explanations and directions regarding the units to

be selected on the coördinate axes should be worked out with the student before he attempts to construct the graph. The selection of cross-section paper will be determined largely by that which is most readily obtained on the market. For this reason, a millimeter paper has been used. The scale on the x-axis is taken 1 unit = 2cm. and on the y-axis, 1 unit = 1cm. The graph can now be constructed from the preceding table for points corresponding to values of y from $y = -0.75$ to $y = +1$. The teacher should insist upon accuracy in locating the points and upon a fine smooth curve, even if this requires repeated attempts in drawing the graph.

Computations From the Graph.

After the student has constructed a satisfactory graph, some drill should be given in reading from it values of x corresponding to given values of y and, conversely, in finding values of y corresponding to assigned values of x. For example, if $y = 0.26$, find the corresponding point on the graph and the required value of x is 1.8, approximately. If $x = 5.2$, it is found that $y = 0.72$. Exercises of the following types should also be given. Find from the graph the number that should replace the question mark in each of the following: $2 = 10^{?}$, $? = 10^{.48}$.

The purpose of these problems is to familiarize the student with the units on the two axes, to enable him to select readily the axis that corresponds to the "number" (x) and to the "exponent" (y), respectively, and chiefly to give him an understanding of the functional relation between the variables x and y. It might be remarked incidentally that the use that can be made of the graph to find values of a given function and to emphasize and clarify the notion of functionality is a feature of graphing that is usually neglected in our mathematics textbooks and consequently in most of the teaching of the subject.

Multiplication of two or more numbers may now be performed by finding from the graph the exponents corresponding to the numbers, adding these exponents, and then finding the number corresponding to this last exponent. Thus, in the problem to find $x = 2.4 \times 3.8$, the computation would be as follows: $x = 2.4 \times 3.8 = 10^{.38} \times 10^{.58} = 10^{.96} = 9.12$. To find $x = 35 \times 1.2$. The exponent of 35 cannot be found directly on the graph, but $35 = 10 \times 3.5$ and so the computation becomes $x = 35 \times 1.2 = 10 \times 3.5 \times 1.2 = 10 \times 10^{.54} \times 10^{.08} = 10 \times 10^{.62} = 10 \times 4.2 = 42$. In general, $x_1 \times x_2 = 10^{y_1} \times 10^{y_2} = 10^{y_1 + y_2} = x$, where y_1 and y_2 are the exponents corresponding to x_1

and x_2 and x is the number corresponding to the exponent y_1+y_2.

The operation of dividing x_1 by x_2 is performed in a similar manner with the exception, of course, that we find the difference in place of the sum of y_1 and y_2.

Involution and evolution are readily performed by use of the graph as is illustrated in the following example:

Find $x = (1.8)^3$.

$$x = (1.8)^3 = (10^{.255})^3 = 10^{.765} = 5.8 \quad \text{(approximately)}.$$

Find $x = \sqrt{6.75}$.

$$x = (6.75)^{\frac{1}{2}} = (10^{.83})^{\frac{1}{2}} = 10^{.415} = 2.6 \quad \text{(approximately)}.$$

The rules for the preceding four operations should be stated by the student. Thus, to multiply two numbers, first, express the numbers as exponents of 10 by finding the values of y corresponding to the given numbers, next, add the exponents thus found, and, finally, find the number corresponding to this new exponent. This number is the required product.

Logarithms.

So far, no mention has been made of logarithms, but the foundation has been laid for its definition, for the rules of multiplication, division, involution and evolution by the use of logarithms, and, in the second illustrative example under multiplication, for the meaning of characteristic and mantissa of a logarithm. The student may now be taught the definition and use of logarithms, or simple problems of computation by use of the slide rules may first be taken up.

If the first plan is followed, it is well to introduce the subject of logarithms by first showing the need of a new definition for the relation $x = 10^y$. The student is already familiar with the fact that in order to be able to solve for y such an equation as $x = 8^y$, the inverse operation of multiplication, namely, division, must be introduced and the solution for y gives the inverse function $y = x/8$. Similarly, to solve $x = y^2$ for y we must introduce the new operation of and symbol for extracting square root. The resulting equation, $y = \pm\sqrt{x}$, gives the inverse function of $x = y^2$.

This suggests the need of introducing a new symbol for expressing y as a function of x in the equation

$$x = 10^y. \tag{1}$$

To do this we define y to be the logarithm of x to the base 10 and write this symbolically, $y = \log_{10} x$. (2)

It should be made clear that equations (1) and (2) give the

same functional relation between the variables x and y, the only difference being the difference in form and that equation (1) expresses x as a function of y while (2) gives y as a function of x. Stated geometrically, the graphs of equations (1) and (2) are identical. The graph that has already been constructed for $x = 10^y$ can therefore be used for $y = \log_{10} x$ and the student is now ready to multiply, divide, raise to a power, or extract a root by logarithms. It soon becomes clear to him that in the rules of these operations that have already been stated it is only necessary to substitute the word logarithm for the word exponent.

The student will have felt that the table of values for x and y that he has constructed and that he obtains from his graph is not sufficiently accurate for most computations. This affords the opportunity for introducing logarithm tables.

As has already been stated, the slide rule can be introduced either before or after he is familiar with logarithms.

RÉSUMÉ.

The method of presenting logarithms and the slide rule as outlined in the preceding requires for preparation no material, such as arithmetic and geometric progressions, which is not already in the ninth grade course. The preparation for logarithms depends upon a careful selection of examples and problems under such topics as graphs, square root of arithmetic numbers, and exponents. The problems so selected give more concrete and practical applications than do the artificial problems so often found in our text books.

Constant use has been made of the notion of functional relation in problems involving tabulation, graph, equation, inverse operations and functions, and computing and reading values of the variables from the graph.

The meaning and use of logarithms are introduced in a natural manner that the ninth grade student is able to comprehend, and not in an artificial way by starting with formal definitions and rules.

The method has been tried with several ninth grade classes in first year algebra in the University High School of the University of Wyoming. The pupils are taught the use of the slide rule and by the end of the year have learned how to compute by logarithms the value of any one quantity when the others are given in such formulas as $A = \frac{1}{2}bh$, $C = 2\pi r$, $A = \pi r^2$, $i = ptr$, $A = P(1+r)^n$. This has been accomplished without sacrificing any of the topics that are now generally contained in the first year algebra texts.

A STUDY OF EXAMINATIONS AND TESTS.

By Mabel W. Arleigh,

South Pasadena, Calif.

It is customary in most schools to give tests or examinations at intervals. The marks received in such tests are given considerable weight. I think most teachers who watch the daily work closely find considerable difference between the daily marks and the examination marks; sometimes one is higher and sometimes the other.

I have tried out many of the standard tests in several subjects, and always obtained some puzzling results. So I began to question the efficiency of tests, and to wonder how I could test the tests. I determined to try out this question with a beginning algebra class. The results may be interesting to other teachers.

For my point of departure let me refer to Thorndyke, and the theory of identical elements. Identical elements may be either "elements of procedure," or "elements of substance." Now, in an examination we use identical elements of substance, that is, we test on the same subject matter as in daily lessons. But what of elements of procedure? In an examination the procedure is always radically changed, is it not? The daily lesson may be oral, or written, or blackboard work, or a combination, but in the test, the pupil has the "idea of the test" to contend with, and that "idea" seems to be a serious hindrance in many cases, according to the personal reaction of each individual pupil. I append the record of the algebra class which I selected for this test, for the year 1918-1919, in the high school at Corning, Calif.

There were twenty-two pupils in the class at different times during the year, but only fifteen were in all the year, so I give their marks only. At the end of eight weeks I gave a written examination, ten questions, marked on the scale of ten, each question marked right or wrong. It was an easy examination but only two pupils passed. I did not return these papers, nor tell them of their poor rating, but I gave them examinations four days in succession gradually increasing their difficulty. The results possessed the usual puzzling features. The class work and home work of all pupils was above passing, but the class average in every examination was below passing. However, all but two pupils passed in at least one of these tests. The object in repeating the tests was to accustom the pupils to the "procedure."

I gave no more examinations till January. Then I repeated the very examination that I had given last in November. Some stood higher, and some lower than two months before. The errors were quite absurd, nervous errors, I should call them. It was the novelty of the test, the difference of procedure, which interfered with their work. I continued daily tests for four days, increasing their difficulty, and the marks now rose to the level of the daily normal. There were some surprising rises.

Two months later I gave four more examinations in succession. The results were similar to the preceding, but the marks were better. Early in May we completed the required work for the year, and I gave a series of final examinations. I offered this inducement. As soon as any pupil passed seven perfect examination papers, he was excused from further examinations, and from home study, and could devote his class time to advanced work. This was advanced algebra, or geometrical construction, or project problems, or logarithms, or mathematical games. In a very short time all the pupils I had had all the year had met this requirement of seven perfect papers. Even the other pupils met it in time.

12 examination marks of 15 algebra pupils on successive days in:

	November				January				March			
M	3	3	4	7	1	5	8	9	8	10	10	10
G	8	9	10		8	9	10	10	10	8	10	10
Z					2	6	3	8				
N	4	8	8	7	4	6	9	8	9	9	8	10
H	7	10	8	7	8	10		10	9	8	9	10
F	8	10	9	5	8	9	7	9	8	9	10	10
O	7	8	7	7	5	9	9	10	7	9	9	10
D	5	6	7	8	4	5	4	8	9	10	10	10
J	6	7	8	6	9	8	9	9	9	7	9	10
C	4	7	9	7	9	8	9	10	10	9	8	10
L	7	8	9	7	9	9	8	10	10	10	10	10
S	4	4	5	8	1	2	4	10	6	5	9	10
B	2	3	5	6	1	5	4	9	3	9	10	9
W	3	5	7	8	3	6	4	10	8	10	9	10
R	3	8	6	5	7	7	9	9	4	8	10	10

Now I think a study of this experiment shows that if an examination is given in a way that differs ever so slightly from the procedure in the daily lesson it is not a fair test. On the other hand if the test is repeated until that method of procedure becomes habitual, then and then only is it a test.

During twenty years of teaching I have again and again seen my best pupils fail on tests purely on account of nerves. Then

some pupil, who in daily work appears weak, stolid, slow, inattentive, will excel in a test, perhaps because the silence helps him concentrate. The examination at infrequent intervals seems to be more a test of nerve than a test of subject matter. If this be true then the mystery of the examination clears. In teachers' examinations we often find the very bright, capable girl who fails, and the dull one who passes. One of the best teachers I have ever known never passes an examination, while some of the poorest I know always pass.

The idea of the standard test is sweeping the country. Pupils and teachers are ruthlessly judged by these. A psychologist from some University was giving tests at a normal school where I was teaching. He took each child alone, and gave him tests to determine his mental age. I observed for a time. Some of his results tallied with my own grading of the pupils, and some differed widely. One boy, aged seven, was brought in. He graded him age 5½, mentally deficient. As a matter of fact the boy was in the fourth grade and exceptionally bright. Later in the day I met the boy, and he volunteered this information, "Say what was that fool test this morning? I sure fooled the old geeser, didn't I? I wanted to hurry back to the library." Yet the boy acted serious and stupid during the test. Quite a number of our bright children were graded low by this doctor, possibly because they did not take him seriously, though he certainly took himself seriously. Some of our dull pupils he graded high.

If the infrequent test is not a true test, what is, and how should the present procedure be modified? Should we give four or five tests in succession each time? If so, should we average the results, or take the last, or take the highest, or take the average of those above passing? For myself, I discarded the failure papers, and repeated the test till I obtained satisfactory results. It was my procedure to drill on daily work till I had satisfactory results, so I did the same with tests. Is that fair? Is any other way fair? If "passing an examination" is a desired result, should we not drill on examinations till the passing of them is accomplished successfully? To teach algebra is not enough. We must also teach the pupil to pass an algebra examination, and to know that he can do it, which is quite a different thing.

I should like to know what experiments other teachers may have made in this direction, or what deductions they may make from mine.

SOME TANGIBLE RESULTS FROM A COURSE IN GENERAL SCIENCE.[1]

By George Mounce,

LaSalle-Peru Twp. High School, LaSalle, Ill.

The motive that gave rise to the course in General Science in the high school had its inception in the desirability of giving the boys and girls, on entering, an appreciation of their industrial, technical, economic and hygienic environment, and the content of the course at any period of its development has been determined by the attitudes of social opinion regarding the prominent sciences of that period.

In tracing the history of General Science we note that it really began with the popular lectures of Faraday, Tyndall and Huxley. Since the prominent science at that time was geography, we can readily see how physiography grew. At first physiography contained much of physics and chemistry, but later it become too specialized, due to the rapid growth of geology in the colleges and to the influence on physiography content by college trained teachers in the high school. A reaction set in for an inductance into the course of more of the physical and biological sciences. Later the economic, social and hygienic points of view were incorporated, thus rounding out a course embracing the industrial, technical, economic, and hygienic environment of the pupil.

In these days when educational arbiters of fate are abroad in the land preaching the gospel of standard tests and score cards, it behooves the teacher of General Science to stop long enough to take an inventory of tangible results, and it is my purpose to set down a few results which, from seven years' experience and observation in active teaching, I consider tangible.

The first and most important result is the creation of a boundless enthusiasm for the wonders of science. I have watched with much interest the effect on the pupil of the unfolding of the wonderful world of science all around him. Nothing that he has studied in the grades approaches it in intensely fascinating interest. From boyhood he has been living in an environment of automobiles, telephones, flash lamps, push buttons, motors, gas meters, kites, and that inherent something which we call natural curiosity has been seeking more or less blindly for an explanation of the why and the law of these familiar things. The demonstrations open up to him a new world. His enthus-

[1]Read before the General Science Section of the C. A. S. & M. T. at Lake View High School, Chicago, Nov. 28, 1919.

iasm sets his face aglow and his appreciation knows no bounds. This enthusiasm and appreciation for the wonders of science is the main spring that impels the boy to carry much useful and helpful information from the class room to the home. In the home he is the center of radiation to all the rest of the family. This new knowledge results in economy of gas in the kitchen range, economy of fire, economy of coal. It results in better ventilation of living rooms, in better lighting as to quality and distribution, in better sanitation about the home. He educates the family until the members are familiar with such terms as calorie, protein, toxin, antitoxin, bacteria, volts, amperes.

For years a large majority of people in our country have been familiar with medical terms. When the physician informs the anxious mother that her husband is suffering cerebro spinal mengitis lethargetic encephyletis she listens with some degree of understanding but when her boy explains to her that the low voltage that dark afternoon was responsible for the poor service that she got out of her electric iron, she looks at him in blank amazement.

I can give you many cases in which students in General Science have carried practical knowledge to their homes and put it into use. A few instances will suffice. One boy was much impressed with the experiment showing the efficiency of tungsten lamps. We had worked out a chart showing the efficiency of different lamps. This boy went home, armed with this table and started an active campaign in favor of the immediate removal of the old carbon lamps that had done duty for years, and a substitution of 40-watt tungstens. His father, a practical business man was soon convinced, and the result was better light for less money.

An electric iron was brought to my lecture room with a request that I tell him why it wouldn't heat like it used to do when his parents lived in a small country town. He had taken the iron to a local electric repair shop, and been told that it was in good working order. The bill was paid but still the iron wouldn't get hot enough for use. We had just developed the idea of electrical pressure, ampere, and watt. I had the boy clean the name plate on the iron with some emery paper and after the rust was removed he found to his surprise that the iron was designed to be used on a 220-volt circuit. He at once reasoned out that the iron was receiving but half the amperage on the

110 volt circuit in his home, and consequently but one fourth of the necessary heat required for practical use. It is needless to say that the boy lost some of his respect for the repair man's knowledge of practical electricity and that General Science gained a staunch friend.

The General Science course often gives the initial impulse that starts many pupils reading scientific books and into investigation on their own accord.

Four years ago a Polish boy came into our high school as a freshman. He was assigned to my class in general science. At once he became interested. He would hang around in the lecture room after the class passed the seventh period, to ask questions. I let him have books on scientific subjects. He read a great many stories of useful inventions, Faraday's History of the Candle, Jink's Chemistry for Young People. I sold him apparatus to equip a small laboratory at home where he carried on some interesting experiments. In his junior year he was in my physics class and during that year he built a fine switch board for our physics laboratory, worked out some very difficult wiring circuits on it. In his senior year he took complete charge of the photographic department that takes all the pictures for our high school annual. He read all the books and magazines on photography that were in our library. He would spend his Saturday morning in the dark room, mastering the fine points of a hobby that will be an ever increasing source of pleasure to him as years pass. He knew nothing of science when he started, but General Science opened up a new field to him.

A third tangible result is that the General Science course establishes a bond of helpful friendship between the teacher and pupil. This bond draws the pupil to the teacher after school hours for information and help on questions in which he is most interested. He finds the teacher a walking encyclopedia of scientific facts. To me this is one of the most interesting phases of science teaching. Woe be unto the prestige of the teacher who is not familiar with the various booksups in wireless or the peculiar eccentricities of detectors. The boy who owns and operates a commercial set will be little interested in an antiquated filings coherer type, unless it be from the historical standpoint.

Recently a boy asked me how the temperature of the water in the cooling system of the Hudson car was controlled by a thermostat. I had to acknowledge that I didn't know but I'd find out. I then showed him the principle of the thermostat. Only the

other day a boy came to me with a drawing for bell ringing device for country railroad crossings. He wanted to know if it would work. I was surprised at the ingenuity of the scheme. As the train approached the crossing a bell would ring and a warning light come on. The light was designed for protection at night. I gave the boy some help regarding contacts, batteries, etc., and urged him to make a working model of his scheme.

The General Science in our high school has been responsible for the steady improvement in the grade of the students electing physics and chemistry. It is acting as a selecting and weeding out device. Pupils who are interested in General Science elect physics in the junior year and chemistry in the senior year.

I made a point of reminding my pupils at the close of the semesters in General Science that if they enjoyed the course they would find physics interesting and helpful in further explanation of the laws of nature in which they live. During the past seven years the total number electing physics who had previously had General Science has increased from 14 per cent in 1912 to 65 per cent in 1919.

Those students who have had General Science rank best in physics and chemistry. They have acquired a working vocabulary of scientific words. Many of them have acquired that scientific attitude of mind that enables them to attack and solve problems with but little help from the teacher.

In an effort to simplify the apparatus used in General Science demonstrations, I have brought into our lecture room such familiar articles as aluminum pans, teakettles, quart cups and measuring vessels; a gasoline stove; a gas plate with two burners, a small one within a larger one; a fireless cooker made from a candy pail, a pair of steelyards for demonstrating the law of levers, electric hot plate, electric iron, a large electric bell, the parts of which are visible to the entire class from the lecture table.

I have collected a various assortment of lamps from the old grease lamp of our ancestors to a modern street arc, and a thousand-watt nitrogen. Many of these articles have been donated to us. An electric shop gave us an electric percolator made largely of glass, also a set of parts showing every step in the manufacture of a tungsten lamp. The Citizen's Lighting Co. let us have a gas meter with glass sides, through which all movable parts are plainly visible. These large pieces of apparatus have given such satisfactory results that I have adapted many of them

to my laboratory work in physics. Toy apparatus command little respect from a real live pupil.

To meet the need of a piece of apparatus to show the relation of temperature to pressure I constructed one from a quart mercury distilling retort and a pressure gauge that read both pressure and vacuum. With this apparatus it is an easy matter to secure a temperature of 150°C. In this retort, beans will cook in a few minutes. This apparatus has replaced the old hypsonometer and mercury monometer which I used to use in my physics classes. To be sure there are fewer thrills occasioned by impacts of thermometers against the ceiling. Such upheavals always result in the discomfiture of the teacher to the huge delight of the pupils.

PEAT AS A GAS PRODUCER.

Peat consumed in a properly designed gas producer yields gas of good quality and in abundant quantity in comparison with the yield from coal and also many valuable by-products. This is perhaps the most effective utilization of peat fuel for generating heat and power, because peat that is to be used in this way does not need to be so carefully prepared nor so thoroughly dried as peat that is to be consumed for domestic purposes or under steam boilers. Gas-producing plants using peat fuel are operated in England, Ireland, Germany, Sweden, Italy, and Russia, but in the United States, although experiments have been made, no gas-producing plants are operated with peat.

SLATE.

The use of slate for roofing is apparently on the decline, although a part of the falling off in production in recent years is due to war-time curtailment of building, according to a report recently issued by the United States Geological Survey, Department of the Interior. The major part of the slate produced in this country is, contrary to the general impression, used on the inside rather than the outside of buildings, for such purposes as making stationary washtubs, electrical switch-boards, and blackboards, and the output for these purposes has been fairly constant for the last ten years. The report may be obtained on application to the Director of the United States Geological Survey, Washington, D. C.

QUICKSILVER PRODUCED IN THE UNITED STATES.

Between January 1 and March 31, 1920, inclusive, 4,899 flasks of quicksilver, each of 75 pounds net, were produced in the United States, according to F. L. Ransome, of the United States Geological Survey, Department of the Interior, who obtained the figures from the producers. This is 852 flasks less than the output in the fourth quarter of 1919 and 1,226 flasks less than that in the first quarter of 1919.

California produced 3,994 flasks, and Texas, Oregon, and Nevada together produced 995 flasks. There were 10 productive mines in California and 1 in each of the three other producing States. Less than 100 flasks were produced by mines outside of California and Texas.

The quicksilver on hand at the mines or in transit to market at the end of the quarter amounted to 4,160 flasks.

The average monthly prices of quicksilver per flask in San Francisco in the first three months of 1920, as quoted in the Mining and Scientific Press, were $89 in January, $81 in February, and $87 in March.— *U. S. Geol. Survey Bul.*

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg.

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A Nyberg, 1044 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

636. *Proposed by Walter Warne, State College, Pa.*

Obtain all the values of x and y in the equations

$$x+y = 14-y^2,$$
$$x^2y^2+xy^2+xy = 600-x^2y^4-2x^2y^3.$$

Solution by M. G. Schucker, Pittsburgh, Pa.

Transposing in the second, equation

$$(x^2y^4+2x^2y^3+x^2y^2)+(xy^2+xy)-600 = 0$$

or

$$y^2+y = 24/x \text{ or } -25/x$$

From the first equation, $y^2+y = 14-x$.

Hence, $14-x = 24/x$ or $-25/x$.

The solutions are: (2, 3), (2, −4), (12, 1), (12, −2), and

$$x = 7\pm\sqrt{74},\ y = [-1\pm(29\mp 4\sqrt{74})^{\frac{1}{2}}]/2.$$

Also solved by C. E. Githens, Wheeling, W. Va.; A. Pelletier, and the Proposer. The irrational solutions were omitted in the solution by Elizabeth Weaver, Sunbury, Pa. Nelson L. Roray, Metuchen, N. J., entered each solution twice but the editor can see no reason for considering them double solutions as that would mean that the curves represented by the given equations pass through the points (2, 3), ... *twice.*

637. *Proposed by A. Pelletier, Ecole Polytechnique, Montreal, Can.*

A, B, C are three numbers having, respectively, α, β, γ digits. Find the number of digits in the expression $(AB/C)^n$.

Solution by the Editor.

The logarithms of A, B, C will have $\alpha-1$, $\beta-1$, $\gamma-1$ for characteristics, and the log $(AB/C)^n$ will have a characteristic equal to $n(\alpha+\beta-\gamma-1)$. Supposing that the mautissa for A and B were .9999 and for C was .0001, the greatest possible error is an increase of $n(1.9997)$. From the characteristic of the logarithm, the number of digits in the expression itself is determined.

Also solved by the Proposer.

651. *Proposed by Walter R. Warne, State College, Pa.*

If x, y, z, be in harmonic progression, a, x, b in arithmetic progression, and a, z, b in geometric progression, show that

$$y = 2(a+b)[(a/b)^{\frac{1}{2}}+(b/a)^{\frac{1}{2}}]^{-2}.$$

Solution by Homer A. Obenauf, Culver Military Academy, Culver, Ind.

From the given facts about the progressions,

$$y = 2xz/(x+z),\ x = (a+b)/2,\ z = \sqrt{ab}.$$

Then, by substituting x and z in the expression for y, we have

$$y = 2(a+b)\sqrt{ab}/(a+2\sqrt{ab}+b) = 2(a+b)/[(a^{\frac{1}{2}}+b^{\frac{1}{2}})/a^{\frac{1}{2}}b^{\frac{1}{2}}]^2$$
$$= 2(a+b)[(a/b)^{\frac{1}{2}}+(b/a)^{\frac{1}{2}}]^{-2}.$$

Also solved by N. Barotz, New York City; H. G. Donovan, Senior at Concord High School, N. H.; T. E. N. Eaton, Redlands, Cal.; Irvin E. Kline, Atlantic City, N. J.; R. T. McGregor, Elk Grove, Cal.; J. S. Morris, Central Square, N. Y.; J. H. Packham, Collegiate Institute, Owen Sound, Ont.; A. Pelletier; J. L. Riley, Stephenville, Tex.; N. L. Roray; M. G. Schucker, and the Proposer.

652. *Proposed by Walter R. Warne.*

A V-shaped trough has an angle of 60°, and is six feet long. A sphere 12 inches in diameter is placed in it and rolls throughout its length. How many revolutions does it make?

Solution by Wm. A. Pagelow, Student in the Industrial Department of The W. L. Dickinson High School, Jersey City, N. J.

The angle of the trough, ADC, is 60°. The $\angle$AOB, formed by the radius of the ball from the point of contact and the horizontal OB, is 30°. Draw AB from the point of contact, A, $\perp$ to OB. Then in the 30° rt. $\triangle$OBA, AB = AO/2. Hence the circumference of the circle formed by the point of contact equals 1/2 the circumference of the ball.

The number of revolutions the ball will make will be twice the number made by a ball 1 ft. in diameter rolling 6 ft. on a plane, or $2 \cdot 6/\pi = 12/\pi$.

The above solution and two others by Edward Kunath and Madison R. Hunt, also students in the same school, were sent in by N. L. Roray. Also solved by Wm. H. Brown, Amherst (Mass.) High School; H. G. Donovan; Irvin E. Kline; J. H. Packham; A. Pelletier; J. L. Riley; Wm. R. Silveys, John Marshall High School, Richmond, Va.; T. F. Tyler, Fremont, Nebr.; and the Proposer. Also two incorrect solutions received. M. G. Schucker was the only one to call attention to the fact that if the trough is closed at both ends, the sphere can roll only 66 in. making $11/\pi$ revolutions.

653. *Proposed by J. Carl Kamplain, Student, University of Chicago.*

Given a triangle ABC with $a = 6$, $b = 5$, $c = r$. Find a point P such that PA : PB : PC $= c : b : a$.

Solution by J. H. Packham.

Since PA : PB $= c : b$ the locus of P will be the circle described on XY as diameter, X and Y being the points of internal and external division of AB in the ratio $c : b$. Similarly, a second locus of P will be a circle that divides BC in the ratio $b : a$. The intersections of the two circles answer the question, and there may be two, one, or no solutions.

Also solved by A. Pelletier. Two incorrect solutions received, one of which assumed that r was the radius of the inscribed circle, in which respect the statement of the problem is misleading.

654. *Proposed by C. N. Mills, Heidelberg University, Tiffin, Ohio.*

Three circles, whose radii are r_1, r_2, r_3, touch one another externally. Show that one of the sides of the triangle made by joining the points of contact, is

(1) $$2r_1\left[\frac{r_2r_3}{(r_1+r_2)(r_1+r_3)}\right]^{\frac{1}{2}};$$

(2) The area of the triangle formed by the points of contact is to the triangle formed by the centers of the circles as

$$2(r_1r_2r_3) : (r_1+r_2)(r_1+r_3)(r_2+r_3).$$

Solution of part (1) by Harold G. Donovan.

Let A,B,C be the centers of the circles whose radii are r_1,r_2,r_3; and M be the point of tangency of circles A and B, N the point for A and C, R the point for B and C. Then

$$MN = 2r_1 \sin(A/2) = \sqrt{(s-b)(s-c)/bc} = 2r_1\left[\frac{r_2r_3}{(r_1+r_2)(r_1+r_3)}\right]^{\frac{1}{2}}$$

Solution of part (2) by Nelson L. Roray.

$$\angle MNR = \angle(A+C)/2. \qquad NR = 2r_2\left[\frac{r_1r_3}{(r_2+r_3)(r_2+r_1)}\right]^{\frac{1}{2}}$$

$$\frac{\triangle MNR}{\triangle ABC} = \frac{MN \cdot NR \cdot \sin(A+C)/2}{AB \cdot AC \cdot \sin A}$$

Writing $\sin A = 2\sin(A/2)\cos(A/2)$, and making the proper substitutions, we get the desired result.

Both contributors solved both parts, but the editor selected what was easiest to print. Some solutions which made no use of trigonometry but only the area of a triangle in terms of its sides are long and complicated with fractions and radicals. Also solved by Irvin E. Kline, Homer A. Obenauf, J. H. Packham, A. Pelletier, J. L. Riley, W. R. Warne.

655. *Proposed by C. N. Mills.*

If a, b, c, the sides of a plane triangle, be in harmonic progression, show that

$$\left[\frac{\sin(A/2)}{\sin(C/2)}\right]^2 = \frac{\cos B-\cos A}{\cos C-\cos B}.$$

I. *Solution by Norman Anning, Ann Arbor, Mich.*

Lemma: When $L+M+N = 180°$, $\sin L\sin M = \cos L\cdot\cos M+\cos N$.

Since $a/c = (a-b)/(b-c)$, $ab-ac = ac-bc$,

$\sin A\sin B-\sin A\sin C = \sin A\sin C-\sin B\sin C$,

$\cos A\cos B+\cos C-\cos A\cos C-\cos B = \cos A\cos C+\cos B-\cos B\cos C-\cos A$.

$(1-\cos A)(\cos C-\cos B) = (1-\cos C)(\cos B-\cos A)$,

$$\frac{\cos B-\cos A}{\cos C-\cos B} = \frac{1-\cos A}{1-\cos C} = \left[\frac{\sin(A/2)}{\sin(C/2)}\right]^2.$$

The first equation of the last line shows that if a, b, c, the sides of a triangle, are in harmonic progression then $1-\cos A$, $1-\cos B$, $1-\cos C$ are also in H. P.; and this, in turn, shows that $\sin^2(A/2)$, $\sin^2(B/2)$, $\sin^2(C/2)$ are in H. P.

II. *Solution by A. Pelletier.*

We have

$$a = b\cos C+c\cos B. \quad (1)$$
$$b = a\cos C+c\cos A. \quad (2)$$
$$c = a\cos B+b\cos A. \quad (3)$$

Subtracting (2) from (1), and (3) from (2), give

$$(a-b)(1+\cos C) = c(\cos B-\cos A)$$
$$(b-c)(1+\cos A) = a(\cos C-\cos B)$$

Dividing, and using the relation $a/c = (a-b)/(b-c)$,

$$\frac{a^2}{c^2}\cdot\frac{1+\cos C}{1+\cos A} = \frac{\cos B-\cos A}{\cos C-\cos B}.$$

$$\frac{\sin^2 A}{\sin^2 C}\cdot\frac{\cos^2(C/2)}{\cos^2(A/2)} = \left[\frac{\sin(A/2)}{\sin(C/2)}\right]^2 = \frac{\cos B-\cos A}{\cos C-\cos B}$$

Also solved by H. G. Donovan, Homer A. Obenauf, J. H. Parkham, A. Pelletier (two), J. L. Riley, N. L. Roray, W. R. Warne (three).

LATE SOLUTIONS.

646. C. M. Cramlet, College Place, West Va.
647. C. M. Cramlet; M. G. Schucker.
648. C. M. Cramlet; N. Anning; Wm. R. Silvey; M. G. Schucker.
649. N. Anning; M. G. Schucker.
650. N. Anning; M. G. Schucker.

Later: from A. Sapthrishi Aiyar, Gen. Sec. of the High School Association, Mayavaram, India, solutions, by K. Gopalau, a student in form VI in the Municipal High School, of problems 636, 647, 650, 651, 654, 655 have been received. It would be a matter of great interest to the readers of SCHOOL SCIENCE AND MATHEMATICS to hear from our friends how mathematics is taught in India, what texts are used, the size and organization of the classes, etc.

PROBLEMS FOR SOLUTION.

666. *Proposed by Daniel Kreth, Wellman, Ia.*

Show that when n is any prime number, $(x-1)^n$ and x_n-1 will have the same remainder when divided by n.

667. *Proposed by Abigail Glenn, Student, Chicago Normal College.*

Through three given points in the same straight line, construct three lines which shall form a triangle inscribed in a given circle.

668. *Proposed by A. Pelletier, Ecole Polytechnique, Montreal, Can.*

Prove that the diameter AD of the circle circumscribing the triangle ABC is divided by BC in the ratio $\tan B\cdot\tan C : 1$.

669. *Proposed by Herbert C. Whitaker, Philadelphia.*

At a certain time, a train overtakes a man, A, and 10 seconds thereafter passes him. The train overtakes another man, B, 20 minutes after

passing A, and 9 seconds thereafter passes B. Counting from the time the train passed B, how soon will the two men meet?

670. *Proposed by Herbert C. Whitaker, Philadelphia.*

What will be the radii of five equal circles which will be tangent to a circle whose radius is 12 inches and also tangent to one another?

AN INVITATION TO THE STUDENTS.

The reader may have noticed that several high school students are sending in solutions to the problems. The editor believes that they ought to be encouraged. After talking over the matter with some of the contributors, it was decided that each month one of the problems should be devoted especially to these future mathematicians. In the present number it is No. 670, and hereafter it will be the last of the five proposed. Teachers are asked to call the attention of the students to this problem, and to encourage its solution. Many high schools have organized clubs in mathematics and their attention should be called to the plan. If the solutions are radically different more than one will be published; the others will be ranked according to judgment shown in omitting or inserting details, and clearness and logic of presentation. Thus, in the solution of No. 652 in this copy, the writer should not talk of $\angle AOB$ before telling how the line AB is drawn. Solutions should give the name of the high school as well as the town.

The success of this plan depends naturally on the teachers. Suggestions are invited as to the nature of the problems, and on such questions as whether trigonometry or advanced algebra should predominate during the first half of the year, the geometry being reserved until the second half.

A NOTE ON NEGATIVES.

By Frank H. McMackin, Ph.D.,

Wm. L. Dickinson High School, Jersey City, N. J.

A suggestion of one method for teaching little folks the *raison d' être* of negative numbers.

Can you recall how you learned to subtract numbers in the primary school? To subtract 5 from 7, i. e., 7—5, you counted out 7 splints | | | | | | | thus, then picked up 1, 2, 3, 4, 5 and those remaining, when counted, gave the answer. There is another way you might have been taught to subtract and probably you would not have found it any more difficult.

Suppose that we have a person who can count but who cannot subtract. We might proceed to teach him subtraction as follows. We would say to him, if you want to subtract 5 from 8, that is to do the problem 8—5, find the number 8 on this chart and starting from there count 5, the other number, spaces to the left — the number you see there will be the answer.

(Do several such problems getting the pupils used to the method and emphasizing the fact one must always begin counting at the minuend.)

Suppose now we tell our pupil to subtract 4 from 3, that is to do the problem 3—4. Not being versed in the niceties of arithmetic, he would not say that it cannot be done but he would immediately find 3 on the chart and count to the left 1, 2, 3, then he would hesitate a moment, count one more space beyond 0 and say, "Well there is the answer but what do you call it?"

That is exactly the point, what name do we give to that answer? The only reason you could not do the problem 3—4 in arithmetic was because arithmetic furnished no way to represent its answer. Algebra furnishes a name for that answer, consequently such a problem can be and is done in algebra.

How can we arrive at a proper name for this answer? Let us go back again to the splint method of substraction and do first the problem

4—3. We have 4 splints and are to subtract 3. If we take one
4—3 splint away we would have left 3 splints but 2 still to be
3—2 subtracted, 3—2. If we take another away we have left 2
2—1 splints and 1 to be subtracted, 2—1. And if we take a third
1—0 one away we have left 1 splint and none to be subtracted.
1 We call 1 the answer and notice that we say nothing in the answer about the fact that we have none left to be subtracted.

In a similar way let us subtract 4 from 3, that is do the problem 3—4. Put down 3 splints. If we subtract 1 we have left two splints,
3—4 and three to be subtracted, 2—3. Take away another one,
2—3 we have left 1 splint and 2 still to be subtracted, 1—2. Tak-
1—2 ing away another we have left no splints and one still to be
0—1 subtracted, 0—1. Here as in the problem 4—3, in writing the
—1 result we do not mention the fact that we have no splints left, we never mention the things we do not have, we simply write —1, read minus one or negative one, which we call the answer to the problem. If we subtract 4 from 3 we have left one to be subtracted, minus one, negative one, —1.

(Similarly for all other negative numbers.)

THE POTASH DEPOSITS OF ALSACE.

One of the outstanding questions of the great war was "Will Alsace be restored to France?" This question, full of national interest and appeal as it was to France and Germany, was of still wider commercial interest, for the only known deposits of potash of proved commercial value in the world except the deposits near Strassfurt, Germany, are in Alsace. The search for deposits in the United States, however, is being continued, and in that search a study of the origin, extent, and value of the deposits in Alsace is likely to be very useful. For this reason Hoyt S. Gale, of the United States Geological Survey, and Frank K. Cameron, of the Bureau of Mines, were sent to Alsace early in 1919, soon after the armistice had been signed, to examine and report upon the deposits there.

Location, Depth, and Character of the Deposits.

The potash deposits of Alsace lie beneath an open stretch of the valley of the Rhine in southern Upper Alsace, about 25 miles north of the Swiss border. No evidence of either the potash or of the large masses of common salt that are associated with it is found at the surface; the potash was discovered only by borings put down in search of coal. Under the German rule a large part of the potash field was owned and operated by the great potash monopoly, the German Kali Syndikat. All the potash properties in this region are now in the hands of representatives of the French Government.

The potash deposits lie at depths ranging from 1,200 to 2,200 feet below the surface, in two beds, one about 60 feet below the other, which are mined through concrete lined shafts, somewhat as coal is mined. The appearance of the deposits in place is striking. They present high walls of sparkling crystalline salts, banded in nearly horizontal more or less wavy stripes of red and white, resembling a part of an immense flag. Much of the crude material is used for fertilizer after crushing only. In the refining processes the mother liquors are used repeatedly, as the accumulation of impurities in them is slow, this being considered one of the advantages which the French field has over the German. The resultant product from the refining of the Alsatian potash is a high-grade chloride. — *U. S. Geol. Survey Bul*

REPORT OF BIOLOGY TEACHERS ON RECOMMENDATIONS FOR A NEW COURSE OF STUDY FOR THE HIGH SCHOOLS OF CHICAGO.[1]

Recognizing the sound pedagogical principles set forth in the pamphlet, Cardinal Principles of Education, by the National Committee on Reorganization, we desire to base our recommendations upon the definition of education which is stated therein as follows:

"Education in a democracy, both within and without the school, should develop within each individual the knowledge, interests, ideals, habits and powers whereby he will find his place and use that place to shape both himself and society toward ever nobler ends."

We hold that biology is unique among secondary school subjects, when properly taught, in serving a greater number of the ends of education than any other single subject and that it should furnish a part of the training of every boy and every girl who is to contribute to the depth and breadth of the democracy in which each is later to take an active part. In support of the contention just stated, we desire to show in concrete form the extent to which biological training contributes to the seven main objectives of education.

I. Health.
   1. Relations of other organisms to man a basis for successful preventive medicine.
      a. Bacteria, beneficial and injurious.
      b. Insects and disease.
      c. Animal parasites.
      d. Rats and bubonic plague.
   2. Knowledge of plant and animal requirements leads to a better understanding of human requirements.
      a. Food.
      b. Air.
      c. Water.
      d. Elimination of wastes.
   3. Knowledge of conditions for proper metabolism in plants and animals makes clear the importance of
      a. Physical exercise.
      b. Bodily cleanliness.
      c. Civic hygiene.

II. Command of fundamental processes.
   1. Closer coordination of English and natural science studies would secure
      a. Definite expression of original thought.
      b. Language as an art.
      c. A saving of needless duplication of effort.
   2. Enthusiasm resulting from a stimulation of a natural interest in living things results in a spontaneity of expression —an end of effective English teaching.

III. Worthy home membership.
   1. The biological sciences teach as no other subject can, fundamental knowledge and relationships of sex.
      a. Home and family the ideal fundamental unit.
      b. Educate for fatherhood and motherhood.

[1] EDITORIAL NOTE: This paper is the report of a committee of Chicago biology teachers of which Mr. Jerome Isenbarger was chairman. It is printed with the desire that it may assist teachers of biology at large in formulating their own ideas and ideals, and thus enable them to approach their administrative officers with a legitimate demand for the required biological course.

c. The approach being natural and biological, a wholesome attitude toward sex and reproduction is secured in mixed classes without offense.

d. Facts of sex and reproduction considered a normal part of knowledge.

e. Biology teachers have gone beyond the experimental stage in teaching sex and reproduction. It is being done, but all pupils in the high school should receive this instruction.

2. Food values and clothing values should be studied by boys as well as by girls.

a. Plant and animal foods.

(1) Luxuries.

(2) Economical selection.

(3) Vitamins.

b. Wool and other animal materials.

c. Cotton and other plant materials.

IV. Vocation.

1. Biological sciences prevocational.

a. Agriculture.

b. Dentistry.

c. Medicine.

d. Nursing.

e. Housekeeping.

f. Horticulture.

g. Forestry.

h. Art.

i. Pharmacy.

2. Biology will help a pupil to select a vocation. A year of a biological science will furnish a strong indication as to whether one of the vocations of the list should be selected or avoided.

V. Citizenship.

1. "Civic biology consists in that group of problems in the control of living nature to solve which requires that a community unite in working together intelligently. Such problems must be made the vital part of the education of every citizen for in no other way can they ever be solved."[2]

a. Flies and mosquitoes, allowed to breed on one's premises, may prove a menace to neighbors.

b. Scale insects and weeds are no respectors of fences.

c. Each individual's carelessness or ignorance affects others. The fact that some people allow the brown rat to breed costs the country $500,000,000 each year.

d. Protection of birds, a civic duty.

e. Biological information presses duties of citizen as neighbor, voter, taxpayer.

f. Cooperation necessary to help control balance of life.

2. "The problem of civic biology is to make it possible for everyone to know what these forces are, for good or for ill, and to understand how to do his part for his own good and for the good of the community."[3]

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[2]Hodge & Dawson, Civic Biology.

[3]Hodge & Dawson, Civic Biology.

VI. Worthy use of leisure.

1. Forms or helps to form lifelong interests leading to active outdoor diversions.
   a. Bird study.
   b. Flower culture and flower and other plant study.
   c. Insect collecting and insect study.
   d. Fishing and hunting.
   e. Excursions at home and abroad.
   f. Poultry keeping.
   g. Bee keeping.
   h. Gardening.
2. Cultivates a love for beauty, a basis of art.

VII. Ethical character.

1. Tends to secure cooperative good will.
   a. Cultivates intellectual honesty,—"an outgrowth of experience with facts which begets faith in the order of nature and in the workings of its laws and the will to order one's life in accordance with them."[4]
   b. Combats evil by substituting knowledge for ignorance.
   c. Cultivates regard for laws and ordinances by making biological facts upon which laws are based common property of the community. Temperance laws came through the education of the public.
   d. Positive effort for good rather than repression.
   e. Making the world a better place in which to live is distinctly ethical.
   f. The producer is on the side of law and order.
2. "If boys of a neighborhood make raising of peaches and grapes impossible, a better remedy than the jail is to start them to raising peaches and grapes of their own."[5]

As biology teachers we are inclined to prefer pupils for our classes who make free choice of our subjects, however, realizing the extent to which biology contributes to the wealth of the people and to the health, efficient living and enjoyment of life of the individual, we desire to recommend that all pupils be required to take a year of a biological science in the second year of the course.

HIGHWAY AND HIGHWAY TRANSPORT EDUCATION CONFERENCE.

The United States Commissioner of Education called in Washington, D. C., on May 14 and 15, a national conference on highway and highway transport education.

The conference was attended by 70 of the leading representatives of the colleges of engineering, heads state highway departments, the automotive industries and the Bureau of Public Roads. The Educational Secretary of the Conference was Dean F. L. Bishop, of the University of Pittsburgh.

Commissioner Claxton in welcoming the members of the conference pointed out that the industrial and economic needs of today had created new demands for engineering education. At present the need for another type of engineer capable of dealing with the pressing problems of highway construction and highway transportation was becoming more and more acute.

[4]Lloyd and Bigelow, The Teaching of Biology.
[5]Hodge, Nature Study and Life.

Thomas H. MacDonald, Chief of the Bureau of Public Roads, called attention to the enormous expansion of the federal and state road building programs. These called for more and better engineers than we have been able to obtain in the past. One-fourth of all engineering students graduated annually, go into highway work.

Mr. Roy D. Chapin, President of the Hudson Motor Car Company, stated that the failure to foresee the present demands of transportation had made it impossible for the railroads to meet the demands for economical transportation especially on the short haul. This places an unusual burden on the motor truck and it makes necessary the training of men capable of dealing with all types of automotive transportation.

Doctor S. P. Capen, Director of the American Council of Education, spoke of the continued expansion of the curriculum in engineering. He warned the educators that undue specialization in highway engineering was not a sound practice and urged that more attention be given the fundamental subjects of engineering.

Doctor Walton C. John, of the Bureau of Education and Executive Secretary of the Conference, said that there are now 150 colleges and universities giving one or more courses in highway engineering. Due to the leadership of Professor Blanchard of the University of Michigan, proper recognition is expected to be given to the new subject of highway transport and cognate subjects.

The conference made definite recommendations as to the number as well as to the education of the men needed in the future by the highway constructors and automotive industries. It was also urged that the States set apart a percentage of the money appropriated for roads to be spent in suitable research in order that the money might be used to the best advantage.

The Committee on Resolutions asked the Commissioner of Education to appoint a permanent committee of 7 to continue working on the problems developed in the conference.

DR. CORNELIUS BETTEN APPOINTED VICE-DEAN OF RESIDENT INSTRUCTION.

Dr. Cornelius Betten, for the past five years secretary of the New York State College of Agriculture, has just been made vice-dean of resident instruction, the appointment to take effect July 1, 1920.

Dr. Betten is a graduate of Cornell, of the class of 1906, where he was fellow in entomology. After graduation he went to Lake Forest College at Lake Forest, Illinois, where he was professor of biology and head of the department. In 1915, he came back to his alma mater as secretary of the college of agriculture.

Under authorization of recent legislation for the college of agriculture, provision is made for three vice-deans or directors; a vice-dean of the college, a vice-director of extension, and a vice-director of the experiment station. The faculty of the college was asked to make nominations, and Dr. Betten was practically selected by his associates, the actual appointment by the trustees of the University being a ratification of the faculty's choice. Professor M. C. Burritt has been for some time vice-director of extension. The vice-director of experiment stations still remains to be chosen.

Under the present plan, Dean A. R. Mann has the aid of three vice-officers as executives in the three main branches of the work of the college; resident instruction, extension, and research.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

FOREIGN EXAMINATIONS.

The editor of this department desires to obtain examinations in NATURAL SCIENCE (as well as other subjects) from schools in France, Belgium, Italy, Spain, Denmark, Sweden, Norway and Finland. Any reader of SCHOOL SCIENCE AND MATHEMATICS in these countries will confer a great favor upon the editor by writing to him upon this subject.

QUESTIONS AND PROBLEMS FOR SOLUTION.

346. *Proposed by J. B. Rees, Klamath Falls, Oregon.*

In Coleman's New Laboratory Manual of Physics, Ex. 23, p. 86 (and also in many other laboratory manuals), there is given an experiment to illustrate the forces of adhesion and of cohesion. This consists in pressing two ground glass plates together and noting the force required to separate them. Cohesion is supposedly shown by having the plates wet when this is done.

(a) Is this adhesion, or cohesion?

(b) What influence has atmospheric pressure upon this experiment?

(c) What has the viscosity of the air to do with the experiment?

347. *Proposed by K. L. Pohlman, Cleveland, Ohio.*

A hammer weighing 2 pounds has a velocity of 12 feet per second at the instant it strikes the head of a nail. Find the force which the hammer exerts on the nail if it is driven into the wood 1/4 of an inch.

348. *Submitted by Wm. A. Hedrick, Central High School, Washington, D. C.*

Readers are invited to express opinions on the following list of questions:

Popular Science Monthly $5,000 Scholarship Examination.

Held throughout the United States June 2, 1920.

These questions are based upon the May, 1920, issue of The Popular Science Monthly.

Instructions.

Answer all questions. Each question has a value of 10 credits.

The candidates will be given three hours only for the examination.

Each candidate will write his name, age, name and location of his school, and his home address in the upper right hand corner of his answer paper.

The candidate will copy and sign the following declaration at the end of his examination paper

"I declare that I have neither given nor received any aid in answering the questions of this examination."

Questions.

1. (a) What makes a baseball curve? (b) Explain, in detail, the physical principles involved.

2. (a) If a boy jumped from a platform suspended from a large spring balance, what effect would this have on the reading of the balance? (b) Explain the scientific principle involved.

3. (a) Explain how daylight may be closely imitated by the use of the "checkerboard reflector." (b) How will this aid industry?

4. (a) Explain the cause of the electrolysis of gas pipes, and describe at least one way of preventing it. (b) How is electrolysis employed in electrotyping?

Textbook of Geology

By AMADEUS W. GRABAU

Recently Professor in Columbia University, now Professor in the Government University of Peking

IN this work one of the most eminent American geologists has sought to provide the standard text upon the subject for the English-speaking race. While in plan and scope the needs of college classes have been kept in view, no pains or expense have been spared in the aim to produce a work indispensable to everyone interested in the accurate and adequate presentation of the present status of the science.

Part I—General Geology. *In October.*
Part II—Historical Geology. *In December.*

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5. (a) Explain fully how you would construct a dry-cell from tinfoil. (b) Give some causes for trouble with automobile batteries.

6. (a) With the aid of a diagram, explain the construction and operation of a searchlight. (b) Show how it may be made to give a parallel or a divergent beam.

7. (a) Briefly describe the considerations involved in stepping down the voltage of an electric current. (b) Explain by use of a diagram, just how you would proceed to make a transformer for stepping down 110-volts.

8. (a) What are the forces which a grand-stand designer should take into consideration for the welfare of the public? (b) To what extent should the community require the contractor to meet these factors for public safety?

9. (a) Describe a quick-action ice-cream freezer. (b) Why does the melting of the ice freeze the cream? Why is salt used?

10. (a) What impressed you most in the article, "Fighting a Fire With Brains"? (b) What scientific principle is involved?

SOLUTIONS AND ANSWERS.

338. *Proposed by K. L. Pohlman, The Warner & Swasey Apprentice School Cleveland, Ohio.*

Rectangle ABCD rests upon side AD. Side AD = 1/2AB. Coefficient of friction = 1/6. If it be pulled by a horizontal force P at C till motion ensues, determine if it will slip on the floor, or begin to turn over round D.

(See Cut in School Science and Mathematics, April, 192 , page 368.)

Solutions from Wm. R. Silvey, John Marshall High School, Richmond, Va.; N. Barotz, New York City, and *H. Tsai, Tangshan, North China.*

Solution by H. Tsai, Tangshan Engineering College, North China.

As the motion to be produced will be either rotation or translation, let us take moments about D then

$$P \cdot AB - W \cdot 1/2 \cdot AD = 0,$$

or

$$P \cdot AB - W \cdot 1/4 \cdot AB = 0,$$

gives

$$P = 1/4W.$$

Also the resisting friction along AD is by the law of friction

$$F = 1/6W$$

Hence any value of P greater than F = 1/6 . W (but not greater than 1/4W) will produce translation, therefore P = W/4 as force necessary to produce rotation shows at once that translation will be produced instead of rotation.

MEETING OF MOTHERS AND PARENT-TEACHERS ASSOCIATION.

The twenty-fourth annual convention of the National Congress of Mothers and Parent-Teachers Associations was held in the Assembly Room, State Capitol, Madison, Wisconsin, June 3 to 8, 1920. It was one of the largest conventions ever held and was marked by a noteworthy spirit of cooperation and progressiveness. In Wisconsin, as in many other states, the Parent-Teacher Association work is being vigorously pushed by the State Education Department.

The following officers were chosen:

President—Mrs. Milton P. Higgins, Worcester, Massachusetts.

Corresponding Secretary—Mrs. George B. Chandler, Rocky Hill, Connecticut.

Recording Secretary—Mrs. Joseph Garibaldi, Charlotte, N. C.

Treasurer—Mrs. Hubert N. Rowell, Berkeley, California.

Auditor—Mrs. Charles H. Remington, East Providence, R. I.

Historian—Mrs. Giles Scott Rafter, Washington, D. C.

Reports showed an increase in membership for the year, April, 1919, to April, 1920, of more than 90,000. The total membership today is over 218,000. The goal for the coming year is 1,000,000 members.

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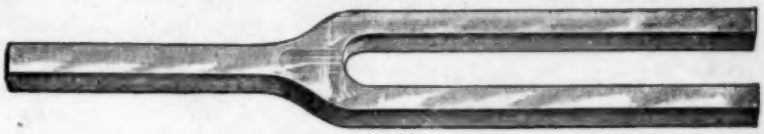

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ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, for July-September; *Lancaster, Pa.; $4.00 per year, 50 cents a copy:* "April Meeting of the Kansas Section," H. E. Jordan; "April Meeting of the Kentucky Section," G. W. Smith; "Fifth Annual Meeting of the Ohio Section," G. N. Armstrong; "April Meeting of the Rocky Mountain Section," G. H. Light; "Mathematics and Life Insurance," Mr. P. C. H. Papps; "Note on the Roots of the Derivative of a Polynomial," W. H. Echols; "Questions and Discussions: Questions—Replies to Question 34," E. Swift, A. A. Bennett and W. A. Hurwitz; "Discussions—Notes on Curves Whose Evolutes Are Similar Curves," G. H. Light; "Functions of Half-Angles of a Triangle," R. D. Bohannan; "The Use of the Vector in Analytic Geometry," V. C. Poor.

American Journal of Botany, for July; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $6.00 per year, 75 cents a copy:* "Measurement of the Catalytic Power of Catalase," L. G. M. Baas Becking and H. C. Hampton; "Early Stages in the Development of Certain Pachypsylla Galls on Celtis," B. W. Wells; "The Upward Translocation of Foods in Woody Plants. II. Is There Normally an Upward Transfer of Storage Foods from the Roots or Trunk to the Growing Shoots?" Otis F. Curtis; "Early Stages in the Development of the Sporophyte of Sphagnum Subsecundum," Geo. S. Bryan.

Condor, for July-August; *Eagle Rock, Los Angeles Co., Calif.; $2.00 per year, 40 cents a copy:* "In Memoriam: Frank Slater Daggett (with portrait)," H. S. Swarth; "Variations in the Song of the Golden-crowned Sparrow (with 4 figures)," Frank N. Bassett; "Additional Notes on the Avifauna of Forrester Island, Alaska," George Willett; "Observations on the Habits of the White-winged Dove," Alexander Wetmore; "A New Ptarmigan from Mount Rainier (with 3 photos)," Walter P. Taylor; "The Californian Race of the Brewer Blackbird," J. Grinnell; "Notes From Field and Study."

National Geographic Magazine, for August; *Washington, D. C.; $3.50 per year, 35 cents a copy:* "Antioch the Glorious" (21 illustrations), William H. Hall; "The Origin of American State Names" (34 illustrations), Frederick W. Lawrence; "The Channel Islands" (25 illustrations), Edith Carey.

Photo-Era, for August; *Boston, Mass.; $2.50 per year, 25 cents a copy:* "True Sepias," Frank B. Howe; "Landscapes with Figures," George W. French; "Warnings to the Photo-Salesman," Charles G. Willoughby; "An Amateur's Confession," Enoch M. Barker; "Sunlight-Portraiture," A. H. Wood; "How Lenses Are Made," Wiener Mitteilungen; "Photographing an Old English House," Carine and Will Cadby; "The Danger of Inadequate Fixation," Wilfred A. French, Ph.D.; "Locally Printing-Up Dense Highlights," The British Journal; "An Historical Parallel in Portraiture," Wilfred A. French, Ph.D.

Physical Review, for August; *Ithaca, N. Y.; $7.00 per year, 75 cents a copy:* "The Existence of Homogeneous Groups of Large Ions," Oswald Blackwood; "Electrical Discharges from Pointed Conductors," John Zeleny; "Some Physical Properties of Nickel-Iron Alloys," L. R. Ingersoll and Others; "The Selective Reflection of Heat Waves by Linear Resonators," E. C. Wente; "The Crystal Structure of Sodium Nitrate," Ralph W. G. Wyckoff; "A Note on the Correction of Contact Difference of Potential Developed in Compton's Modification of the Quadrant Electrometer," Otto Stuhlman, Jr.; "Note on the Electromagnetic Force Between Two Atoms," G. A. Schott.

Popular Astronomy, for August-September; *Northfield, Minn.; $4.00 per year:* "John Alfred Brashear, 1840-1920" (with Plate XIX), Frank Schlesinger; "South of the Equator," S. C. Hunter; "To the Amateur Observer," Miss Elizabeth Emory; "Aitoff's Equal-Area Projection of the Sphere," R. L. Faris; "Note on the Temperature of the Earth's Interior," William O. Beal; "The Conon Bradley Snow Fields," William H. Pickering; "Tidal Action," F. J. B. Cordeiro; "The Solar Eclipse of 1920, November 10, as Visible in the United States," William F. Rigge.

Popular Science Monthly, for August; *Modern Publishing Co., New York; $3.00 per year, 25 cents a copy:* "How Much Gas Can You Breathe?" "Tomorrow's Weather"; "The Greatest Sea Fighter of Them All"; "Surgeon to Worn-Out Documents and Books"; "A Fire Engine to Raise Sunken Treasure"; "Carrying the Power on a Separate Boat"; "Unloading Thirty Railroad Cars in An Hour"; "Carrying Perishables in Refrigerator Trucks."

Scientific Monthly, for September; *Garrison, N. Y.; $5.00 per year, 50 cents a copy:* "The poem of the Philosopher Theophrastos upon the Sacred Art—A Metrical Translation with Comments upon the History of Alchemy," Dr. C. A. Browne; "The Economic Problem of the Ozark Highland," Carl O. Sauer; "Giant Suns," H. H. Turner; "The Medical and Allied Professions as a State Service," Dr. D. F. Harris; "The Economic Importance of the Scientific Work of the Government," Dr. Edward B. Rosa; "Democracy's Opportunity," Dr. Stewart Paton; "The Methods of Procedure in the Analysis of Heredity," Charles Zeleny; "A Simplified Musical Notation," Edward V. Huntington.

Torreya, for May-June; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $1.00 per year, 30 cents a copy:* "Additions to the Flora of Western Oregon During 1919," J. C. Nelson; "Length of Day and Flowering and Fruiting"; "Pin Oak in Nebraska," Raymond J. Pool.

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JOHN LOSSEN PRICER IN HIS RELATION TO NATURAL SCIENCE.

By H. J. Van Cleave,
University of Illinois.

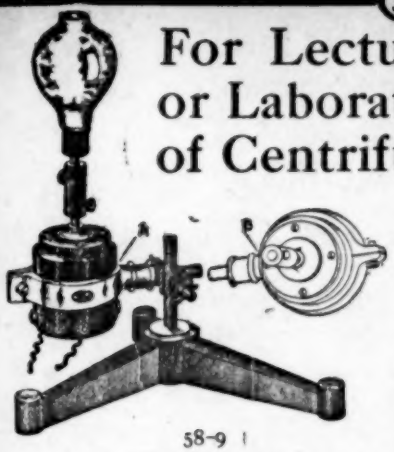
No one of the younger men of this generation has had a more wholesome or a more profound influence in the solution of the problems relating to natural science in our middle-western public schools than has John Lossen Pricer. Because of his active participation in the various educational and scientific organizations and institutions of this state, his death will be especially keenly felt by his co-workers in Illinois.[1]

In 1907 Mr. Pricer received both the A. B. and the A. M. degrees from the University of Illinois, then after two years as principal of the Marshall Township High School he returned for one year to the University of Illinois as an assistant in botany. At the end of that year of study he accepted the position as professor of biology at the Illinois State Normal University, where he became one of the most influential members of the faculty and a highly esteemed citizen. Much of the development of the Senior College in that institution was made possible because of the untiring manner in which he as a member of the committee insisted upon the erecting of suitable standards and the convincing of other institutions that these standards were being maintained.

His training and his work brought him into intimate relationship with an unusually large number of different aspects of the educational system. This diversity of experiences naturally fitted him for an unparalleled understanding of the educational problems pertaining to the field of his major interest, the natural sciences. It is not surprising, then, that he became a worthy successor of men like S. A. Forbes and J. M. Coulter in the active leadership of shaping the general educational policies of the secondary schools of the state in matters relating to the teaching of biological sciences. His activity in this direction found its fullest expression through the meetings and the publications of the State High School Conference. His invariably lucid analysis of a problem, his persuasive presentation, and his decided sincerity always assured for him an audience of appreciative hearers, many of whom were glad to profit by his wealth of suggestions.

During the past four years Professor Pricer served the Illinois State Academy of Science as its secretary. An examination of the Academy programs during this period reveals a strong emphasis upon educational and public health problems, in great measure due to his ardent desire to keep before the people of the state the necessity of more thorough knowledge of science as a requisite to good citizenship.

Through his exceptional ability as a teacher, he has trained many teachers who have studied under him and have partaken of his zeal in the advancement of the cause of science. Yet his ardor for teaching never deadened his sincere appreciation for the new in science. Frequently he would refer to his student days and recall the supreme joy of discovery that came to him when in the course of his investigation he first realized that he had unearthed a truth concerning nature about which the entire world previously had been ignorant. In spite of this fascination with which he viewed the results of original investigation, he saw that his varied experiences had offered to him a peculiar opportunity to serve the cause of science through devoting his life to a study of the problems concerning science teaching. Problems such as he attacked are frequently shunned by others because of the realization of



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the fact that they are too big for one man to solve alone, yet he was content to invest his energy and his ability in the hope of contributing something toward their solution. Those who knew most intimately of his work know that he gave much and only regret that he could not be allowed a few more years to round out some of the many things he had so well in hand at the time of his death.

John Losee Pricer was born January 10, 1871. While looking after business interests in Risco, Mo., he died very unexpectedly on August 19, 1920. For some months he had been subject to heart trouble, a recurrence of which caused his death practically without warning.

BOOKS RECEIVED.

Laboratory Manual of Elementary Colloid Chemistry, by Emil Hatschek, London, Eng. Pages viii+135. 12.5×19 cm. Cloth. 1920. $2.00 net. P. Blakiston's Son and Co., Philadelphia.

Lighting from Concealed Sources, by J. L. Starr, Chief Engineer, National X-Ray Reflector Company. 246 pages. 21×26 cm. Cloth. 1919. Chicago.

Teacher Training Departments in Minnesota High Schools, by Lotus D. Coffman, Dean of the School of Education, University of Minnesota. Pages viii+92. 13×20 cm. Paper. 1920. General Education Board, 61 Broadway, New York City.

What Will Metric Standardization Cost? World Trade Club, 148 pages. 9×21.5 cm. Paper. 1920. 50 cents. World Trade Club, San Francisco, Calif.

The High School Boy and His Problems, by Thomas Arkle Clark, Dean of Men, University of Illinois, Urbana. 194 pages. 13×20.5 cm. Cloth. 1920. The Macmillan Company, New York.

Elementary Applied Mathematics, by W. Paul Webber, University of Pittsburgh. Pages ix+115. 13.5×21 cm. Cloth. 1920. John Wiley and Sons. New York City.

The Individual and the Curriculum, Experiments in Adaptation, by the Faculty of the Francis W. Parker School. 161 pages. 15×23 cm. Paper. 1920. 45 cents. The Frances W. Parker School, Chicago.

The Professional Preparation of Teachers for American Public Schools. Bulletin 14, by William S. Learned, William C. Bagley and others. Pages xix+475. 19×25 cm. Paper. 1920. The Carnegie Foundation, 576 Fifth Avenue, New York City.

Practical Chemistry, by N. Henry Black, Roxbury Latin School, Boston, and James B. Conant, Harvard University. Pages x+474. 13×19 cm. Cloth. 1920. The Macmillan Company, New York City.

Practical Physics by Robert A. Millikan and Henry G. Gale. University of Chicago. Revised edition. Pages x+462, 13×19 cm. Cloth. 1920. $1.64. Ginn & Co., Boston.

Animal Husbandry, by John L. Forney and Rolla C. Lowry, University of Wisconsin. 351 pages. 13×19 cm. Cloth. 1920. American Book Co., New York City.

Vocational Arithmetic, by Clarence E. Paddock, Wentworth Institute, Boston, and Edward E. Holton, Technical High School, Springfield, Mass. Pages x+232. 12.5×18.5 cm. Cloth. 1920. D. Appleton & Company, New York.

Heredity and Evolution in Plants, by C. Stuart Gager, Director of the Brooklyn Botanic Garden. Pages xv+265. 113 illustrations. 14×20 cm. Cloth. 1920. P. Blakiston's Son & Company, Philadelphia, Pa.

Bulletin No. 11, Statistics of State School Systems, by H. R. Bonner,

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Department of the Interior. 155 pages. 30 cents. Government Printing Office, Washington, D. C.

Bulletin No. 63, Natural Science Teaching in Great Britain, by Committee appointed by the Prime Minister. 106 pages. 14.5×23. Paper. 1920. 15 cents. Government Printing Office, Washington, D. C.

The American Red Cross in the Great War, by Henry P. Davidson, Chairman of the War Council of the American Red Cross. 302 pages. 13.5×19.5 cm. Cloth. 1920. The Macmillan Company, New York.

Introduction to Vocational Education, by David S. Hill, President of the University of New Mexico. Pages xvii+483. 13.5×19.5 cm. Cloth. 1920. $2.00. The Macmillan Company, New York.

Modern Junior Mathematics, Book Three, by Marie Gugle, Assistant of Schools, Columbus, Ohio. Pages xiii+246. 13.5×19 cm. Cloth. 1920. $1.00. The Gregg Publishing Company, 77 Madison Ave., New York.

Dietetics for High Schools, by Florence Willard, Washington Irving High School, New York, and Lucy H. Gillett, Boston, Mass. Pages xx+201. 13×19.5 cm. Cloth. 1920. The Macmillan Company, New York.

Elements of Physics, by R. A. Houstoun, University of Glasgow. Pages viii+221, 202 figures. 14.5×22. Cloth. 1919. $1.90. Longmans, Green & Company, New York City.

BOOK REVIEWS.

Armenia and the Armenians, by Kevork Aslan, translated for the French by Pierre Crabites. Pages xxix+138. 13.5×20 cm. Cloth. 1920. The Macmillan Co., New York City.

In these strenuous times, especially applied to Armenia, this book is very timely. It gives a history of Armenia and the Armenian people from the earliest times down to the beginning of the Great War, in 1914. The author is an Armenian who is perfectly familiar with the history of his people, and to Americans who wish to become more familiar with the trials and tribulations through which the Armenians have passed, they could not do better than to secure a copy of this book. The author has made profuse use of other texts bearing upon the history of these folk. With this little book as a guide, one would be able to become familiar with the entire literature of the Armenian people.

It is printed on uncalendered paper, which makes it quite easy to read.

C. H. S.

Zoology, a Textbook for Colleges and Universities, by T. D. A. Cockerell, Professor of Zoology, University of Colorado. Cloth. xii+568 pages. Illustrated with maps, charts, drawings, and photographs. Price $3.00. Yonkers-on-Hudson, New York, World Book Company.

This text is rather a unique college course because it stresses the cultural side of Zoology rather than the educational one. It is surprisingly deficient in the details on Anatomy and Embryology commonly found in higher texts, and for those courses which aim to develop the highly trained and skillful technician the book is unfitted. For example: Protozoa as a phylum are discussed in the brief limit of seven pages, one-third of which is illustration. The classic clam is pictured and described within one and one-half pages, and this text is descriptive of the shell exclusively. But Protozoa later becomes a subject of a chapter upon heredity and of another chapter upon disease. Such treatment occurs again and again within the book. The modern problems centering about the Chromosomes, those referring to heredity, sex, genetics, and society

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are well treated. The story of early man is told in the language of very recent investigation. Geographical distribution is given fairly ample treatment, and scattered throughout the book are some very fine biographies, those of Agassiz, Pasteur, Fabre, and others.

The reviewer is of the candid opinion that the use of this book might prove a very beneficial change in the routine of some colleges where crystallization has set in. It would, in this environment, be very much disliked and yet it might work as a leaven to overcome this bias in the course and in the professor. Continued use of such a text as this would doubtless popularize the zoology department, and yet it would not produce any highly trained students unless it were supplemented by a very exacting laboratory course, or succeeding courses, of the old line character.

We welcome the appearance of such a text with the hope that it may bring about a revival of interest in Zoology and add an extension of Zoological teaching in the American Commonwealth. H. B. S.

General Botany, by H. D. Densmore, Professor of Botany in Beloit College. 459 pp. 289 fig. Ginn and Co. 1920.

This is a wholly new botany course. The plan is new, the method of treatment is new, the illustrations are nearly all new. It is the embodiment of the present day desire to present the plant as a living active organism, getting its food and force from the environment.

The plant is described first as a creature with a hereditary body organization or plan. With its hereditary organs it responds to environmental influences in an adaptive way. For an understanding of these organs and adjustments, cellular structure is next described. Growth is studied as an expression of cell activity. Chapter VI presents the structure of stems, roots and leaves. Stem structure is here for the first time presented in its modern aspect, viz. the woody stem as primitive, from which is derived the herbaceous dicot and finally the monocot. Probably no one doubts that this is the evolutionary sequence. No one who has tried teaching it to beginners in this order will doubt that the presentation is at once easy and logical and satisfying.

Section III treats of physiology. Photosynthesis, digestion, assimilation, and respiration are concisely and clearly outlined. Here Professor Densmore has introduced a summary of the whole discussion up to this point under the caption "Seasonal Life of the Plant." He outlines the entire nutritive relation of the plant from the germination of the seed until it again produces seed. The annual bean, the biennial white sweet clover, and the perennial herb and tree (locust) are used as examples. This is a very striking review of the life of the plant. Absorption, conduction and transpiration of water are next described.

Section IV gives vegetative and sexual reproduction in flowering plants, followed by a clear statement of the work of Darwin and Mendel in plant breeding.

Part II gives the usual series of life-histories. A unique feature here is the emphasis on ecological relations. The descriptions of alternation of generations in ferns, gymnosperms and angiosperms are very well worked out and especially well illustrated. Stem anatomy of ferns and gymnosperms is also well portrayed. The doctrine of leaf-gaps is fully presented.

Part III gives "Representative Families and Species of the Spring Flora." Our common trees are described and illustrated. Taxonomic, ecologic, sylvic and economic characteristics are discussed. Thirteen of the more prominent families of flowering herbs are described and illustrated.

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The book is avowedly brief and concise. It is intended for the use of beginning classes in colleges and universities, and can follow any of the high school botany courses now given. For a half year course, pages 1-212 give an excellent unit. Instead of giving a mass of material from which the teacher must select, it gives a minimum, and that of the most clear cut, universally accepted material. Upon this the teacher may build in any way and to any extent. It is expected that pupils will use the text in the laboratory, reading appropriate portions while the specimens are in hand. A laboratory guide is promised this fall. This will have references to the text and copious questions for the pupil to answer as he examines his specimen.

While this book in this edition is not free from errors of text and figure it is the only really modern botany that has yet appeared. It is to be hoped that a new edition will soon be called for, wherein minor corrections can be made. H. S. C.

Experimental Organic Chemistry, by Augustus P. West, Ph.D., Professor of Chemistry, University of the Philippines. First edition, pp. xiii+469. Illustrated with drawings and diagrams. Cloth. 1920. $3.00. World Book Co., Yonkers-on-Hudson, N. Y.

A new departure, in that it consolidates in one volume a laboratory manual of organic chemistry and an abridged textbook. This new contribution to our chemical literature has many novel and commendable features.

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While the college teacher of experience may well work up his own textbook and laboratory manual, as Professor West has done, the many younger men will find in this new book a workable manual for a laboratory course to accompany or to follow a lecture course in organic chemistry. F. R. W.

Laboratory Manual of Elementary Colloid Chemistry, by Emil Hatschek. First edition, pp. viii+135. 1.5×12.7×18.7 cm. 20 illustrations. Cloth. 1920. $2.00 net. P. Blakiston's Son and Co., Philadelphia.

This little manual attempts to provide for the laboratory study of colloid chemistry the equivalent of the regulation laboratory manual in the older established courses in chemistry.

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A number of references to the literature follow each chapter.

The manual should be added to all chemical libraries even though no formal course in laboratory colloid chemistry is contemplated, for it should prove useful to anyone who is reading any text on the principles of colloid chemistry, as such texts seldom give sufficient detail in their accounts of the experiments cited by way of illustration.

F. B. W.

The High School Boy and his Problems, by Thomas A. Clarke, dean of Men at University of Illinois. Pages vii+194. 13.5×19.5 cm. Cloth. 1920. Macmillan Co., New York City.

There are few men better equipped to write on this subject than the author of this book. It is one of the best books of its kind that has ever been published. It goes directly to the core of the matter and presents the problem of the boy with which parents and teachers have to deal in a most forcible manner, making suggestions and explaining how it is best to deal with all types of boys. His knowledge is gained by intimate contact with thousands of high school fellows as well as college men and thus enables him to present his views in a most convincing manner.

The book surely will be immensely helpful to all those who are dealing with boys. The parent, too should read the book, likewise the boy, as he may be convinced, if inclined to go the wrong way, that from all points of view it is best for him to follow the precepts laid down for him in the book.

This book makes good reading for any and every one; it is splendidly written, fascinating, and to the point. It deals with all phases of a boy's life and should be in the library of every home. It deserves and undoubtedly will have a wide circulation.

C. H. S.

What Will Metric Standardization Cost, by The World Trade Club. 148 pages. 9+22 cm. Paper. $0.50. 1920. The World Trade Club, 681 Market St., San Francisco, California.

This is a splendid compilation of the views of influential men and corporations concerning the universal adoption of the metric system of measurements. The World Trade Club deserves encouragement for the tremendous efforts they are making towards the adoption of the only kind of measurements worthy of consideration in a civilized nation. All readers of this journal should possess themselves with a copy of this interesting book and themselves do everything to promote the efforts that are being made for the adoption of the metric system. This journal has always stood and worked for this system and was one of the pioneers of 20 years ago in advocating the universal adoption of this system of measurements.

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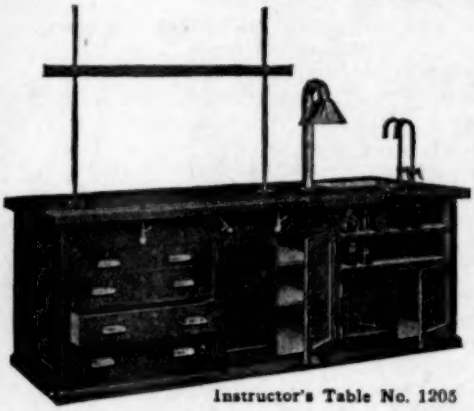

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Second Course in Algebra, by W. B. Ford, Professor of Mathematics in the University of Michigan, and Charles Ammerman, the William McKinley High School, St. Louis. Pages ix+299. 13×19 cm. $1.28. 1920. The Macmillan Company, New York.

The first part of the book gives a review of the first course through quadratic equations. The method of treatment is largely inductive, being based upon solved problems and other illustrative material rather than upon any attempt at proof or formal demonstration. Part II presents the usual topics of the advanced course with excellent lists of problems and thorough explanations of the more difficult topics. The table of powers and roots give an opportunity for the pupils to learn how to use tables, which they will find to be a great advantage in technical pursuits. H. E. C.

Number by Development, Vol. III, Grammar Grades, by John C. Gray, A. M., Superintendent of Schools, Chicopee, Mass. Pages xx+514. 13×19 cm. 1919. J. B. Lippincott Company, Philadelphia.

The purpose of this volume is to offer to the teacher outlines in detail of the teaching steps in decimal fractions, percentage, interest and its applications, and average, so that she may be able to conduct her work steadily and consistently on a logically arranged development plan. The method of solving problems in percentage by the use of diagrams is of considerable interest and should help the pupils to master this rather difficult topic. At the conclusion of each subject short methods of solution are outlined. Definitions of all the principal terms are suggested, and there are rules that every pupil should memorize after he has mastered the principles or processes which they describe. H. E. C.

Household Arithmetic, by Katherine F. Ball, M. A., Vocational Adviser for Women, the University of Minnesota, and Miriam E. West, M. A., Teacher of Mathematics, Girls Vocational High School, Minneapolis. Pages 271. 14×20 cm. 1920. J. B. Lippincott Company, Philadelphia.

If it is true that girls need more training in the kind of mathematics used in everyday life than is afforded in the traditional course, this *Household Arithmetic* is most admirably worked out to remedy the defect. The authors have used the subject matter of home economics for this text, which aims to enable girls to understand and to interpret the economic problems in their own homes; to develop skill in the computations and the methods of reasoning involved in everyday affairs so that arithmetic may become a tool in effective living; and to make girls readily see controlling number relations in practical situations.

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Applied Arithmetic, by N. J. Lennes, Professor of Mathematics in the University of Montana, and Frances Jenkins, Professor of Elementary Education in the University of Cincinnati. Book 2. Pages ix+294. Book 3. Pages ix+340. 13×19 cm. 1920. J. B. Lippincott Company, Philadelphia.

The first mentioned book covers the work in arithmetic in the fifth and sixth grades, while the second book covers the work in the seventh and eighth grades. It has been the purpose of the authors to find the

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Plane Trigonometry for Secondary Schools, by Charles Davison, Sc. D., Mathematical Master at King Edward's High School, Birmingham. Pages 334. 13×19 cm. 1919. Cambridge University Press.

The first part of this book includes the ordinary course of elementary trigonometry, though graphs and the solution of equations are treated rather more fully than usual. The second part, Chapters XVII-XX, deals with inequalities, approximations and errors, de Moivre's theorem, and series. There is an abundance of problems, including many excellent applications. This is a good reference book for the teacher in this country since it contains many types of problems not found in our textbooks. H. E. C.

Applied Mathematics, by Eugene H. Barker, formerly Head of the Department of Mathematics in the Polytechnic High School, Los Angeles, Calif. Pages viii+247. 13×19 cm. 1920. Allyn and Bacon, New York.

This book furnishes in teachable form an adequate treatment of the fundamental operations of arithmetic, a consideration of ordinary business transactions, practice in the use of letters and simple algebraic operations in handling formulas, mensuration problems, and a study of graphic charts. The examples and problems have been selected from many fields, industrial, commercial, mechanical, agricultural, and as far as possible are such as occur in the household, on the farm, in the factory, and at the office. Those who are interested in practical courses in arithmetic will do well to examine this book. H. E. C.

Infinitesimal Calculus, Re-issue, by F. S. Carey, M. A., Professor in the University of Liverpool. Pages x+352. 14×22 cm. $4.25. 1919. Longmans, Green and Co., New York.

This book is not written for any particular group of students; it is designed for those who wish to use calculus as an instrument in the attainment of further knowledge. It is therefore essentially a book of practical mathematics. The fundamental ideas are explained at great length, and the student is advised to return again and again to the earlier chapters. If this were generally practiced there would be fewer failures in this subject. The exercises are numerous and cover many fields. Students in calculus using this as a reference book will find much help in understanding the principles of the subject and in applying them in the solution of problems. H. E. C.

Elements of Vector Algebra, by L. Silberstein, Ph.D., Lecturer in Natural Philosophy at the University of Rome. Pages 42. 14×22 cm. $1.60. 1919. Longmans, Green and Co., New York.

The author states that while this book is scarcely more than a synoptical presentation of the elements of vector algebra covering the needs of those engaged in geometrical optics, it is hoped that it will serve the more general purpose of providing everybody unacquainted with the subject with an easy introduction to the use of vector algebra. In such a brief and condensed discussion of the subject the author has succeeded in giving the reader a clear and rather easily grasped understanding of the use of vector algebra. H. E. C.

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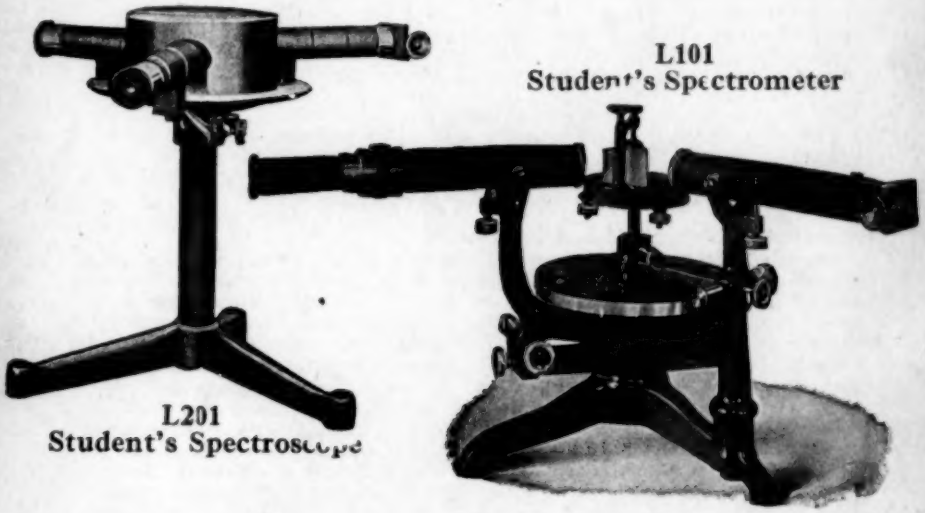

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